Bachelor Thesis

Industrial Engineering

DESIGN OF A WRAP YARN PROTOTYPE

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SUMMARY

The aim of the project is to develop the design of a prototype capable of producing a specific type of yarn: wrap spinning. This method consists, as its name suggests, in wrapping continuous filaments around a ribbon of parallel fibres.

First of all, in order to go in depth into the textile area, there have been studied the principle characteristics of the fibres that compose the yarns. Moreover, it has been described the process followed by the fibres that constitute the yarn.

Hereafter, there have been exposed the most common methods used at the present time for producing yarn and specifically the one that will characterize the prototype design: wrap yarn technology.

The study of different machines capable of making wrap yarn has been done for the purpose of analysing the principles in which they are based and later on presenting a range of prototypes designs. The different alternatives will be compared and contrasted to identify the positive aspects of each proposal.

Several books and Internet pages have been used in order to be highly documented within the framework of yarn technology. Furthermore, visits to *Schappe Techniques* and *Bergère de France SA* were greatly beneficial to the project development.

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1. PREFACE

1.1 ORIGIN OF THE PROJECT

The faculty of engineering *ENSISA*, belonging to the *Université d'Haute Alsace,* offers different types of engineering but above all outstands the textile one. The facilities of the university offer a textile laboratory where several machines for producing yarn can be found. However, there is not such a machine capable of making wrap yarn.

For this reason, it was offered the possibility of making a project focused on that specific type of machine. The aim of the project is then designing a prototype characterized for being able to produce wrap yarn. The conception will count with some characteristics of other existing machines.

The possible construction of the prototype in the future will permit the university progress in the technologic field.

1.2 MOTIVATION

The textile engineering was an unknown field for the writer, as the studies that she follows do not comprise this area. The realisation of this project will permit acquaint the writer with the textile field and have the opportunity to enlarge the knowledge with such an old sector as the textile is. Moreover, the textile field is nowadays very present in our lives as it is in expansion.

1.3 REQUIREMENT KNOWLEDGE

Prior to designing the prototype it is necessary to be familiarized with the subject of the project. This step is really important in order to progress successfully along the project.

First of all, two books have been read for going deeper into the field: *'Fundamentals of spun yarn technology'* and *'The Rieter Manual of spinning'*. Together with the information extracted from Internet it has been done an introduction to the textile area, mainly about the fibres characteristics and the process that fibres have to follow before making the yarn.

Once all this concepts have been well understood it is time for starting the design of the prototype.

2. INTRODUCTION

The principal aim of this project is to design a prototype capable of creating a specific type of yarn: wrap yarn. In order to achieve the purpose of the scheme it has been done an exhausted study of the existing machines.

The prototype will have to be able to treat different types of fibres. Depending on the function of the yarn created the desired characteristics will change.

The prototype will have to deal with:

- Different types of length fibres: long and short.
- Different types of fibres from which the yarn is obtained: ribbon and roving.

Once the objective of the prototype has been well understood it is now time to project the ideas of the conception of the machine. This has been done thanks to the research of all the other existing machines. During the project different options of the prototype will be exposed to identify the positive aspects of each proposal.

3. CHARACTERISTICS OF THE FIBRES

It is important to notice that textile fabrics are made of yarn, which is at the same time formed by fibres. Taking this into account, first of all, there will be a brief introduction to the fibres.

A fibre is a single filament of a natural or synthetic material used to manufacture products such as yarn.

There are different types of fibres that can be used for making yarn; they can be classified, according to their origin, into natural and synthetic fibres. Natural fibres are those that are obtained from plants, animals and geological processes and can be grouped into:

- Vegetable fibres: generally based on arrangements of cellulose (cotton).
- Wood fibres: unlike vegetable fibres, they come from tree sources.
- Animal fibres: consist largely of particular proteins (silk, wool, mohair, angora).
- Mineral fibres
- Biological

On the other hand, synthetic fibres are those made by the humans, in other words, its chemical composition, structure and properties are significantly modified during the manufacturing process.

When choosing the fibre that best suits the textile fabrics desired, some characteristics will have to be taken into account. Subsequently the three most important characteristics will be briefly developed.

3.1 FIBRE LENGHT

There are two types of fibres that can be distinguished by their length:

- Long fibres: such as wool, with an average length ranging from 35 to 350 mm.
- Short fibres: such as cotton, whose fibres can have an approximate length between 13 and 34 mm.

Fibre characteristics must be such that when processing them for obtaining the yarn, have to survive without noticeable shortening.

The staple length is a measured estimate of the principal length of a tuft of fibres. It is commonly represented by the staple diagram, which shows, for a random sample taken from a fibrous mass, the proportion of fibres that are greater than the specified lengths.

Fibre length influences in:

- Spinning limit
- Yarn strength
- Yarn evenness
- Handle of the product
- Luster of product
- Yarn hairiness
- Productivity

3.2 FIBRE FINENESS

The fineness determines how the fibres are presented in the cross-section of a yarn of given thickness. The way in which the fibres are positioned will affect on the strength and on the evenness of the yarn.

The fineness of a fibre influence in the next properties:

- Spinning limit
- Yarn strength
- Yarn evenness
- Yarn fullness
- Luster
- Handle
- Productivity process

Fibre fineness is specified by *tex*, a unit of measure for the linear mass density of fibres, yarns and thread and is defined as the mass in grams per 1000 meters. Nowadays, it is more common to use the *decitex*, abbreviated *dtex*, which is the mass in grams per 10000 meter.

Examples of fineness would be:

- Cotton: 1,7 dtex
- Wool: 2,2-38 dtex

- Polyester: 1-6 dtex

In the case of cotton fibre, the fineness is also associated with the fibre maturity. Indeed, the cotton fibre consists of cell wall and lumen, and the fibre wall thickness will determine its maturity. Immature fibres will lead to a loss of yarn strength and a high proportion of short fibres among other things.

3.3 FIBRE STRENGTH

Strength is defined as the amount of force required for breaking the fibres. Although nature produces countless types of fibres, most of them are not suitable for making yarn because they are not strong enough. For this reason, strength is commonly known as the predominant characteristic of a fibre.

The strength of a yarn depends on how well its constituent fibres can equally share the tension induced by the load applied to the yarn. The finer the fibre, the greater is the number of fibres in a particular count of yarn to share the applied load; finer fibres therefore tend to give stronger yarns.

Moreover, the strength of the fibres depends on the climatic conditions, and more specifically on the moisture environment. The strength of the cotton fibres increases with the moisture as they become less rigid when saturated with water. For this reason, before testing a fibre it should be known the air conditions and the time it has been exposed to them.

Strength measurements are reported in terms of *grams per tex* (*g/tex*). Therefore, the reported strength is the force in grams required to break a bundle of fibres one tex in count. Some significant breaking strengths of fibres are:

- Polyester fibre: 35-60 cN/tex
- Cotton: 15-40 cN/tex
- Wool: 12-18 cN/tex

As it has been said before, as to produce a fabric for a particular end use, the fibre type has first to be chosen, and then spun into a yarn structure of specific properties so that the subsequent woven or knitted structure give the desired fabric characteristic.

Generally there are two types of yarns, continuous filament and staple fibres. The firsts ones are basically unbroken lengths of filaments, which are twisted or entangled to produce a continuous filament yarn. Moreover, continuous filament can be further subdivided into monofilament and multifilament. And this last one can also be divided into textured, twisted or flat.

On the other hand, staple fibres are those which relation between length and diameter is greater that 600. They can be divided into long fibres, like wool, or short ones, like cotton.

4. PRINCIPLES OF YARN PRODUCTION

Once it has been explained the fibres and the yarn characteristics it is time to focus on the production of the yarn. In order to produce the yarn it is necessary to purchase fibres, which are obtained in large fibre bales. The material at this point is called raw material. In this stage, fibres do not have a definite orientation or configuration. The high percentage of them is entangled and in the case of cotton there are different kind of particles that will have to be removed. In consequence, the first step of the yarn production is cleaning.

4.1 OPENING AND CLEANING

Natural fibres can contain different types of impurities shown below:

- Vegetable matter:
  - Husk portions.
  - Seed, stem, leaf, wood fragments.
- Mineral material:
  - Earth, sand.
  - Dust
- Sticky contaminations:
  - Grease, oil, tar.
  - Additives.

All these particles can lead to extreme disturbances while processing the yarn. On one hand they can damage the machines used during the process and cause accidents in the factory. While on the other hand, impurities can lead to foreign fibres in the yarn, making unusable the entire yarn.

New spinning processes are being more sensitive to foreign particles as machines are developing more accurately time to time.

Cleaning occurs progressively using pin or saw-tooth wire-covered rollers. The compressed fibre mass is opened up and the solid impurities are released to become waste. In situations where there is a high level of particulate impurities, a combination of chemical and mechanical cleaning may be necessary. The chemical products should degrade the physical properties of the impurities without damaging the fibre.

Talking about the industrial process, hundreds of kilograms of fibre should be separated per hour (kg/h) in order to manufacture the demand of yarn to be economically viable. For this reason, cleaning has to be done progressively; separating such an amount of fibres per hour into individual fibres is not practical.

To eradicate this problem is usual to break up the hundreds of kilograms of fibre into a collection of progressively smaller and smaller clumps, called tufts. This process is done until sufficiently small tufts sizes are obtained for separating into individual fibres. This process of breaking up the fibre mass into smaller clumps is known as opening.

Light particles of impurities, such as dust, are freed and can be removed by air currents. Larger particles like leaf, seed, dirt and sand, which are lodged between fibres, are removed by beating the tufts against grid bars.

The intensity of opening depends on the:

- Raw material: thickness and density of the feed, fibre coherence, fibre alignment and size of flocks in the feed.
- Machines: type of feed, opening and clothing.
- Speeds: of the devices and throughput speed of the material.
- Ambient conditions: humidity and temperature.

The fibre properties of different clumps and also the ones of the same clump can differ between each other. Therefore, it becomes necessary to mix the fibre tufts for obtaining a homogenous mass for consistent yarn properties. This process is called blending. Moreover, blending influence favourably the behaviour of the material during processing and achieve effects by varying colour, fibre characteristics and so on.

The evenness of the blend must be in two directions: the longitudinal and the transverse. Unevenness in the transverse direction can lead to an uneven appearance of the finished product.

4.2 CARDING

Opened and cleaned materials arrive at the carding stage in the form of small tufts composed of entangled fibres. The purpose of carding is to disentangle these tufts into a collection of individual fibres in the form of a web of fibres, and afterwards consolidate this collection into a sliver of the required count.

The machine used to carry out this stage is called card, and it consists of oppositely disposed sets of teeth or small wire hooks. There are two possible distributions of the clothing surfaces relative to each other: the carding and the doffing arrangement.

In carding disposition the teeth face in opposite directions. In order to enable carding to take place, in *figure 4.1*, v_1 must be greater than v_2, or v_2 must be in the opposite direction to v_1. During this process fibres are separated and aligned.

Afterwards, doffing takes place, characterized because the teeth of both clothing surfaces face the same direction. Here, there is a deliberate transfer of material from one clothing surface to another, but v_1 must be greater that v_2.

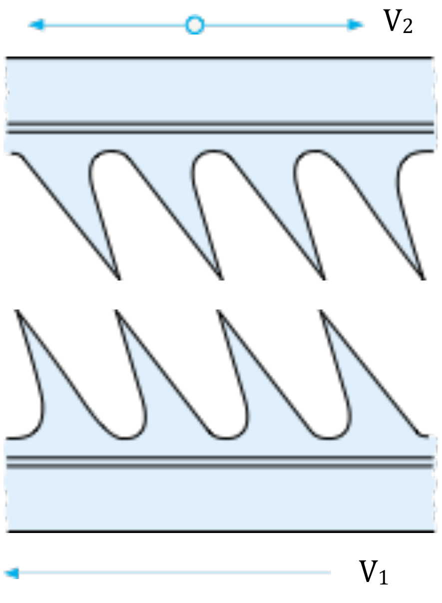

Figure 4.1 *Carding disposition. The Rieter Manual of Spinning.*

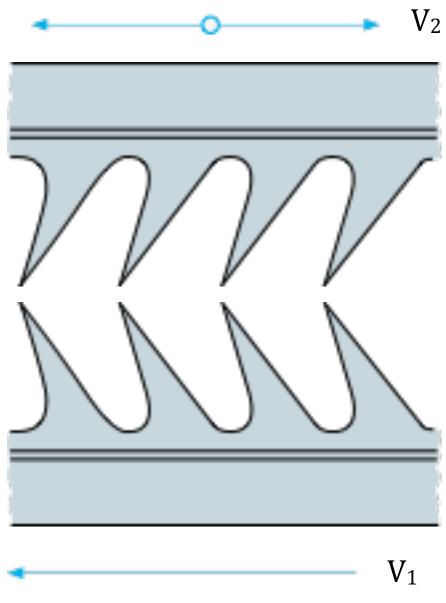

Figure 4.2 *Doffing disposition. The Rieter Manual of Spinning.*

4.3 COMBING

Combing is understood as the process by which the quantity of short fibres and remnant fragments of impurities are minimized to give a clean sliver, with the vast majority of the constituent fibres in a straightened and parallel state. That is why combing prepares the sliver for making spinning possible, with low irregularities and a cleaner appearance.

4.4 DRAWING

Drawing includes the operations of doubling and drafting.

Doubling consists on placing several slivers in parallel and combine them by using a roller draft equal to the number of slivers. Doubling improves the irregularity and the blend of the fibres. After doubling the ensemble of slivers is referred as ribbon.

Ribbon fibres start being parallel, but they are not still straightened as it would be desired. For this reason, in order to improve the alignment, the fibres will be thinned by stretching; the mechanical action is called drafting, and the amount by which it is stretched is the draft.

The count of the sliver will decrease, so drafting is an attenuating action, and the draft is equal to the factor by which the sliver count is reduced. Therefore, the next equation can be applied:

$$Draft = \frac{stretched\ length}{initial\ lenght} = \frac{initial\ count\ (tex)}{final\ count(tex)} = \frac{V_2}{V_1} \qquad \text{(Eq. 4.1)}$$

The drafting unit is constituted by several pairs of rollers by which the ribbon passes through. Bottom rollers are made of a metallic material, they are fluted and driven by an engine. Top rollers are covered by rubber and they are responsible of pressuring down onto the bottom rollers and driven through frictional contact. The speed of the rollers increases as the fibres move forward, and this gradient makes a permanent alignment to the fibres.

The distance between two pairs of rollers has to be higher than the maximum length of the fibres. Otherwise, fibres would break.

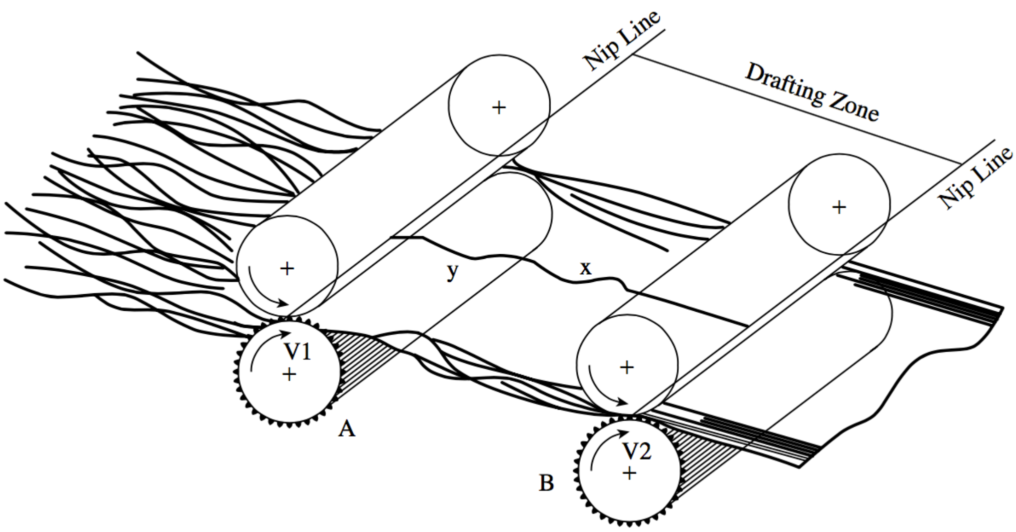

Figure 4.3 *Drafting rollers. Fundamentals of Spun yarn technology.*

4.5 TWISTING

After drawing stage, some ribbons are twisted in order to acquire strength. Without doubt the strength depends on the height of the twist.

Twist is obtained with the aid of a hollow spindle, where a bobbin is placed and in which the ribbon is wrapped thanks to a component called flyer. The flyer is mounted on the top end of the central spindle, and has a hollow leg through which the ribbon travels to the bobbin. Due to the centrifugal force the ribbon receives a twist and forms the roving. Afterwards, the roving is wrapped around the bobbin.

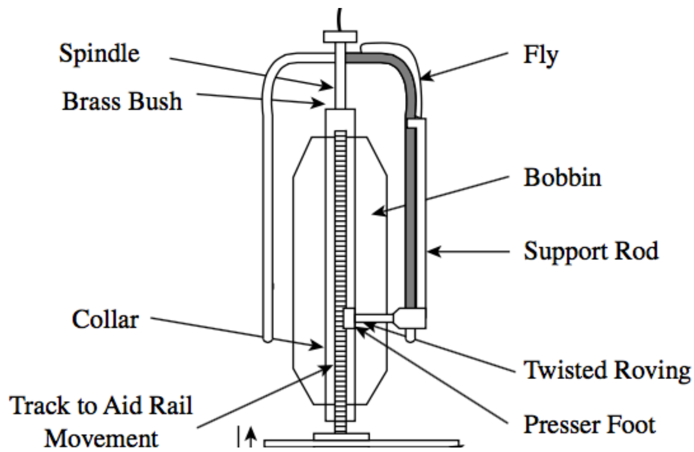

Figure 4.4 *Twisting device. Fundamentals of Spun yarn technology.*

5. SPINNING SYSTEMS

Once the fibres have passed for all the stages explained above they are prepared for finally making the yarn. There is a wide range of mechanisms used for obtaining yarn but some of them still experimental or are not used for commercial issues. In the points that follow, it will be explained those methods commonly used:

- Ring spinning
- Open-end spinning
- Air jet spinning
- Wrap spinning

What makes a mechanism different from another is the type of fibres that can be spun, the economics of the process and the suitability of the resulting yarn structure to a wide range of end uses.

5.1 RING SPINNING

First of all, the fibres, usually in the form of a roving, pass through different pairs of rollers, called drafting system, explained above. The distance between each roller and its pair decreases as the fibres move along in order to compress the fibres. It is important to notice that drafting system can only be used when the fibres of the material to be processed do not have a wide range of length.

After the rollers, there is a yarn guide called lappet, and below the lappet there is a ring with a spindle situated at its centre. The lappet, the ring and the spindle are all coaxial. The traveller, made of metal, has the shape of the letter C and it is clipped onto the ring.

While the traveller goes around the spindle a tubular-shaped bobbin is made. The ring rail moves up and down the length of the spindle, so as to wound the yarn onto the bobbin in successive layers. Therefore, the diameter of package that is being build is lower than the ring. The path followed by the yarn is consequently from the nip of the front rollers of the drafting system, through the eye of the lappet and the loop of the traveller, and onto the bobbin.

The yarn wound onto the bobbin at the same linear speed as the front rollers are delivering the fibres. And this happens due to the rotation of the spindle that can be up to 25000 rpm. So the traveller pull around the ring and the yarn pull through the traveller and wound onto the bobbin.

As the yarn is being created the bobbin increases in width, which means that the traveller speed has also to increase. Moreover, the traveller speed will also change with the movement of the ring rail to form successive yarn layers on the bobbin. The bobbin has commonly a conical shape because it gives easy unwinding of the yarn without interference between layers.

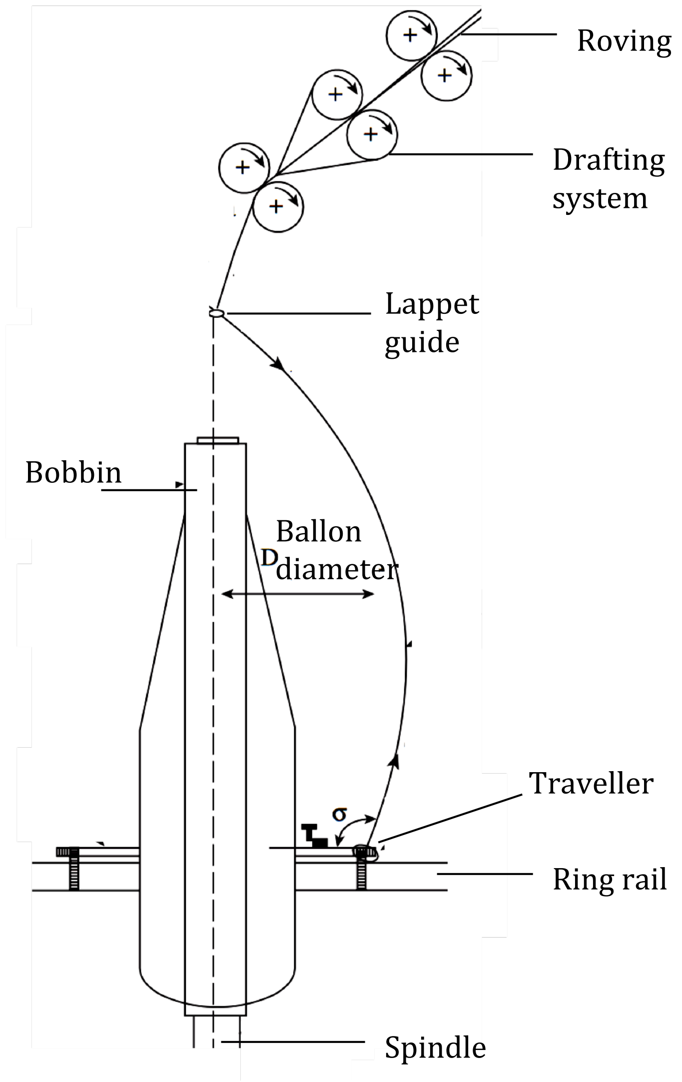

Figure 5.1 *Ring spinning system. Fundamentals of spun yarn technology.*

Figure 5.2 *Traveller. Fundamentals of spun yarn technology.*

Although ring spinning is the spinning system most used, it has a very low production speed as it is restricted by the frictional contact of the ring and the traveller and by the yarn tension. Furthermore, the dimension of the bobbin, where the yarn is wrapped around, is restricted by the size of the ring, and this requires stopping the machine in order to change it. Nevertheless, what makes it useful is the great number of fabric end uses with advantageous properties obtained. Moreover, it offers a wide range of fineness.

5.2 OPEN-END SPINNING

Open-end spinning consist on collecting twisting individual fibres onto the open end of a yarn, while this one is rotating, so as to create a continuous yarn length. Afterwards, the spun yarn is wound to form a package.

In this particular system, twisting and packaging are two separate stages. Expressed in other words, the twisting action occurs simultaneously but separately from winding.

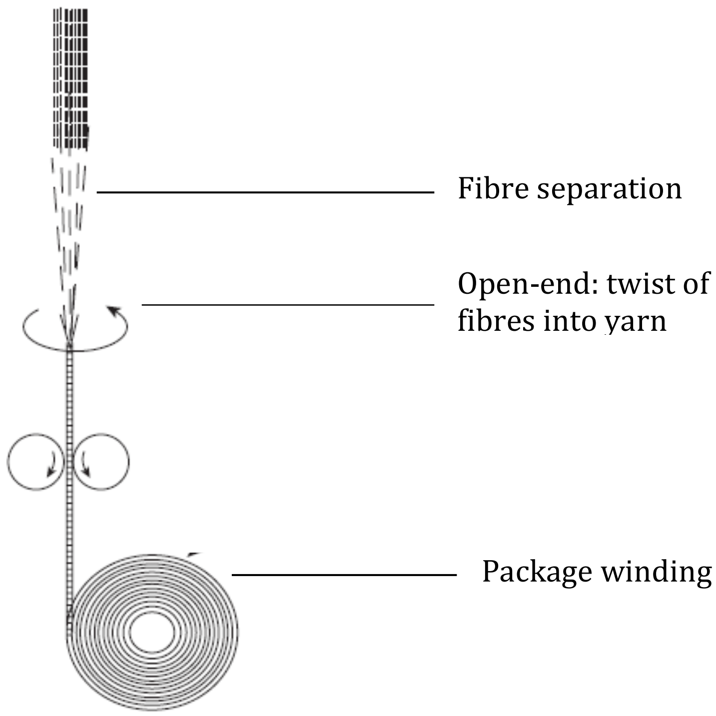

Figure 5.3 *Basic diagram of the Open-end spinning. Fundamentals of Spun yarn technology.*

According to this spinning system, the most common system is the rotor spinning because a greater variety of yarns can be spun by this technique. In rotor spinning, fibres come into the rotor system in the form of a sliver. Then, a feed roller and a feed plate push the sliver into the opening roller. Here, the rotating teeth of the roller separate and comb out the individual fibres from the sliver. Afterwards they are conducted by the transport channel into the rotor.

Thanks to the trash ejector attached to the opening roller, fibres are additionally cleaned. Once the fibres reach the rotor, they are attached to the open end of the yarn. That is possible thanks to the partial vacuum in the rotor that sucks the tail end of the yarn into the rotor. The rotation of the rotor pulls the yarn end into contact with the collected fibre ribbon. At the same time the rotor rotates, the tail end is twisted and the yarn starts to create itself.

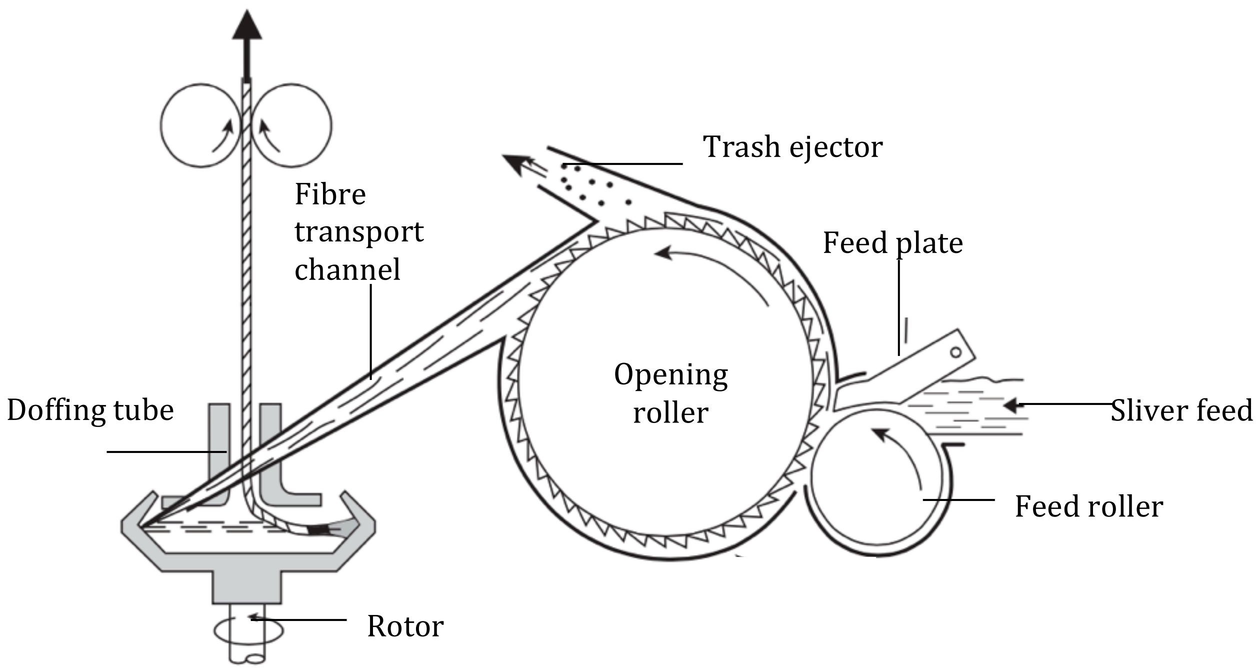

Figure 5.4 *Features of rotor spinning system. Fundamentals of Spun yarn technology.*

5.3 AIR-JET SPINNING

Air-jet spinning is a method of surface fibre wrapping. It consists of, firstly, three pair of rollers whereby the sliver pass through. Afterwards, the fibres enter into two air-jets that have a central tubular channel and, inclined to this spinning channel axis, there are some nozzles (generally four) by which compressed air is injected. The air creates a vortex flow and is expanded into the channel. Two velocity components can be distinguished: a circular motion of the air around the channel circumference, and the movement of the air to the channel outlet. The mixture of these two speeds is responsible of making the wrap yarn.

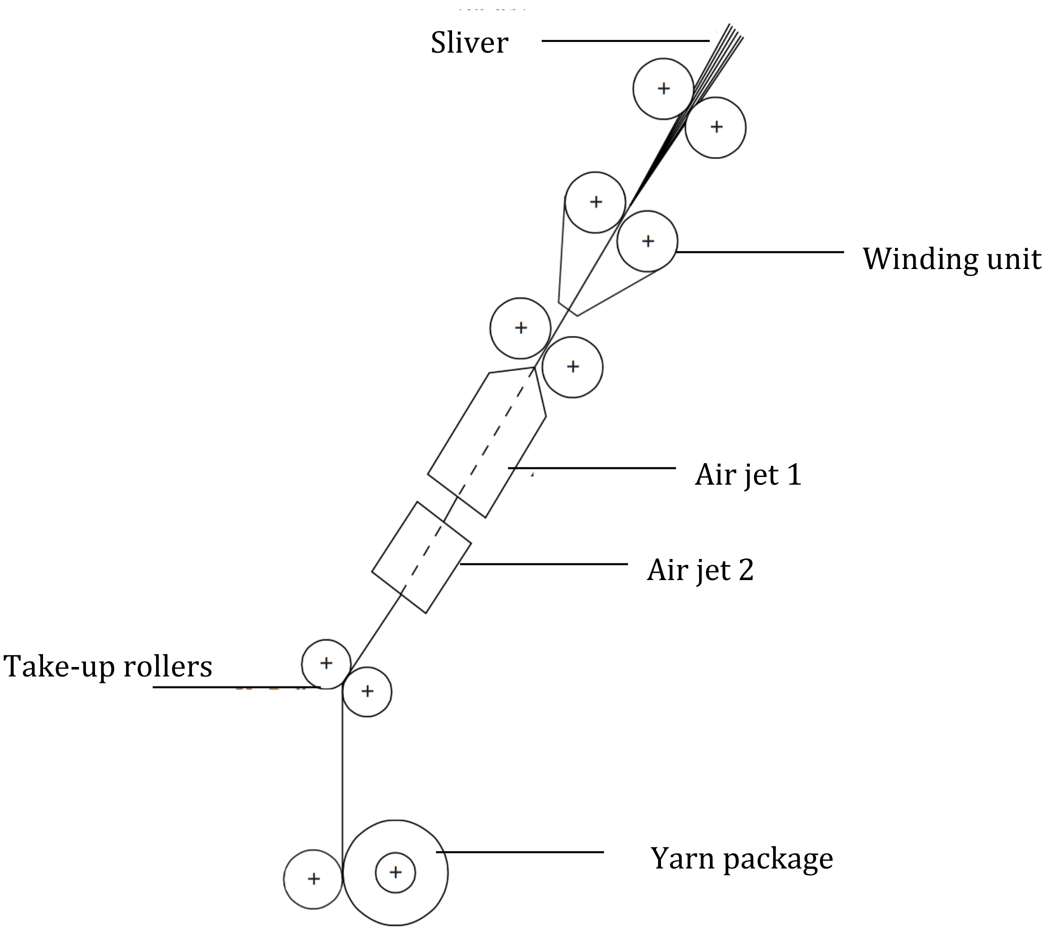

Figure 5.5 *Air jet spinning. Fundamentals of Spun yarn technology.*

5.4 WRAP SPINNING

Wrap spinning is a spinning system that consists, as its name suggests, in wrapping a continuous filaments around a ribbon of parallel fibres. Wrap spinning has become the subject of renewed interest in recent years as it offers good qualities for a wide range of applications.

There are several methods through which wrap yarn can be obtained. However, there is one that stands out, the hollow spindle system. In fact, the design of the prototype, aim of the present project, consists in using this type of spinning system.

Hollow spindle system has become generally accepted as the most important method of wrap yarn production. Hereafter, an explanation of its process will be given.

First of all, the ribbon passes through a drafting arrangement that can be of three, four or five rollers. Once the ribbon is drafted, it goes directly to a hollow spindle on which is mounted a bobbin of filament, also called binder yarn. Is in this stage where the drafted ribbon receives a false twisting. The twister can be located, depending on the machine, on either at the top or at the bottom of the spindle.

The filament, which will be wrapped around the ribbon, emerges from a rotating bobbin mounted on the hollow spindle and it will also pass around the pin twister. Nevertheless, as the filament bobbin rotates with the spindle, the filament is not false-twisted. As the ribbon is untwisted, the rotation of the pin false-twister makes the ribbon and the filament stay together, and since the filament is the finer of the two counts, it wraps the ribbon.

Finally, the take-off rollers lead the resulting wrap yarn to a winding device, as it is showed on the picture below. The yarn obtained consists of two components: one twist-free staple fibre component in the yarn core and a filament wound around the core. The filament exerts radial pressure on the fibre core resulting in frictional forces acting between the individual components, which, together with the wrapping filament, are responsible for yarn strength.

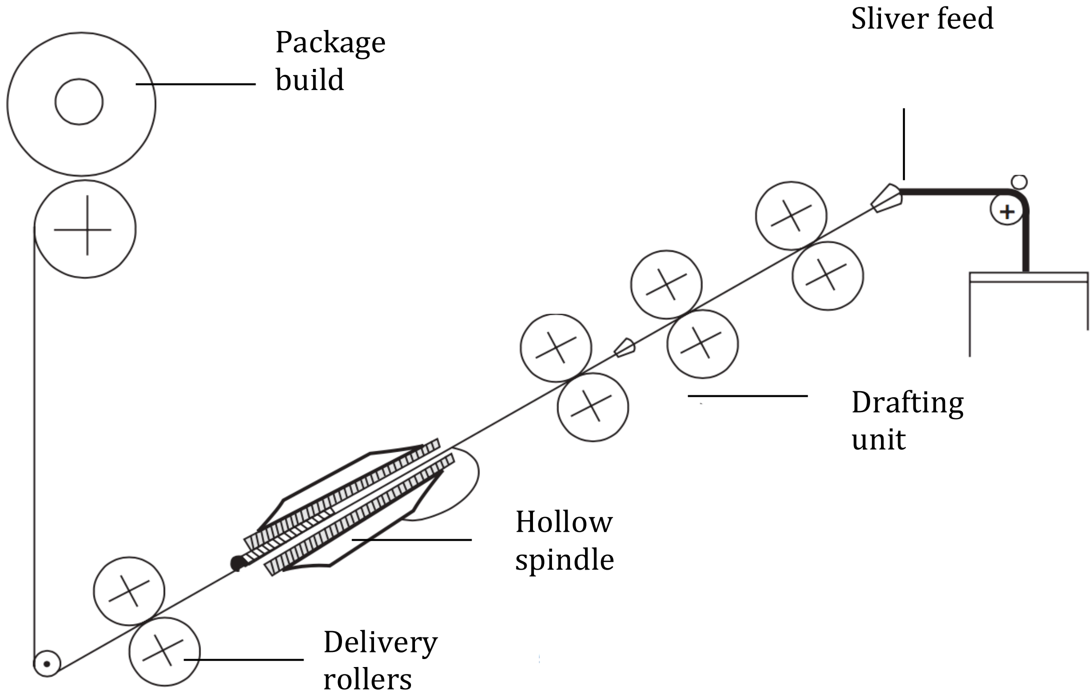

Figure 5.6 *Features of wrap spinning system. Fundamentals of Spun yarn technology.*

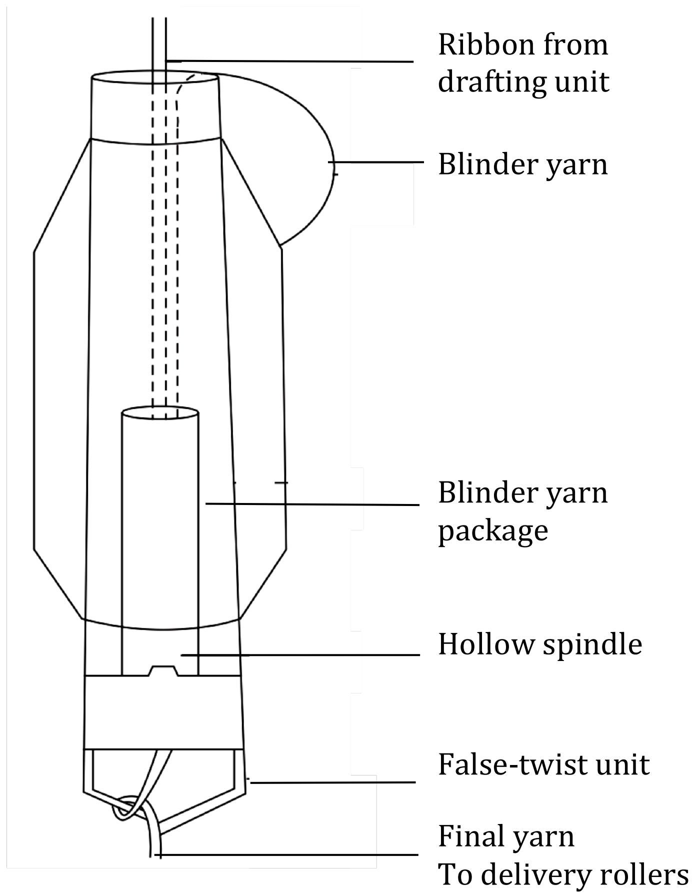

Figure 5.7 *Hollow spindle wrap spinning system. Fundamentals of spun yarn technology.*

The relationship between the tension of the binder and that of the base material is very important. Differences in filament tension may occur as the filament unwinds during spinning, caused by the shape of the package, the amount of filament on the package or the spindle speed. Perfect wrapping is achieved when end stage elongation of the fibre structure and the filament yarn is reached simultaneously.

On one hand, when yarns are spun with low filament tension, the filament yarn is wound loosely about the fibre structure and there is hardly any constriction. On the other hand, if the filament is very tight it will break before the fibres have reached their point of rupture.

The frequency of filament yarn wraps around the core, ergo the wrapping density, makes influence on the strength, the elongation and the torque. For example, wrap yarn tenacity increases as the wrapping density increases until an optimum, after which, the tenacity starts to decrease. Moreover, it is clearly known that the use of stronger wrapping filaments leads to a higher yarn tenacity. However, stronger filaments are usually those coarser and this means that the volume of the filament will be higher and therefore the bobbin in which it is bounded will store less quantity of filament.

Figure 5.8 *Wrap yarn. The Rieter Manual of Spinning. Volume 1 – Technology of Short-staple Spinning.*

Comparison with ring spinning

Wrap yarns can be successfully produced with fewer fibres per cross-section than normal ring-spun yarn. However, the fewer fibres are there, the higher is the theoretical limit of irregularity.

Yarn uniformity is almost the same or better than the one of ring spun yarns, and the wrap yarns are also smoother and less hairy.

The tenacity of the yarn is known to be higher than the conventional yarns due to the higher level of interfibre friction caused by the contact between the parallel staple fibres bound and compressed by the wrapping filament.
Fibre elongation is higher also in wrap yarns. Moreover, another characteristic of this type of yarns is the lack of torsion. Compared to those fibres made by ring spinning methods, they do not cause spirality in the knitted construction due to the lack of twist.

6. THE PROTOTYPE

Once the wrap spinning has been well defined the design of the prototype will be explained. The aim of the machine is to create wrap yarn by using different types of fibres. For this reason the prototype will have to be able to:

- Treat different fibres lengths: long and short.
- Treat different types of fibres from which the yarn is obtained: ribbon and roving.

The prototype will consist on different parts, which will be explained in what follows this section of the project.

First of all, there will be a drafting unit so as to treat the fibres and prepare it for making the yarn. In order to operate with the different types of fibres this part of the machine will have to accommodate depending on the fibres treated.

Afterwards, the hollow spindle or wrapping unit will take place. Is in this part of the machine where the yarn is produced, that is to say, where the ribbon of parallel fibres is wrapped around the fibres or a continuous filament.

Once the yarn is made, it has to be stored in a bobbin for being used later on, what is called the storage unit.

Throughout the description of the prototype different alternatives will be proposed in order to compare and contrast them.

6.1 DRAFTING UNIT

Drafting consists, as it has been said in the principles of yarn production, of three pair of rollers that attenuate the fibre mass. In order to treat long and short fibres the distance between each pair of roller will have to be different for not breaking the fibres. If a fibre is pinched at the same time by different rollers it will break, due to the difference of speed of each roller that will be transmitted to the fibre.

Moreover, the input material may be presented in two ways: ribbon or roving.

Hereafter, two alternatives about the drafting unit will be exposed. Both proposals, no matter the length of the fibre and its type, will have to deal with certain parameters established. The output speed of the treated material will have to be of **100 m/min**. In order to obtain the input speed as well as the one from the middle roller, it will be taken into account the following relations:

	Ribbon	Roving
V_{mdl}/V_{in}	1,5	1,5
V_{out}/V_{in}	150	50

Table 6.1 *Speed relations.*

The rotational speeds of each pair of roller are the followings:

$$W_{in}(rpm) = \frac{V_{in}\,(m/min)}{\pi \cdot D(m)} \qquad \text{(Eq. 6.1)}$$

$$W_{mdl}(rpm) = \frac{V_{mdl}\,(m/min)}{\pi \cdot D(m)} \qquad \text{(Eq. 6.2)}$$

$$W_{out}(rpm) = \frac{V_{out}\,(m/min)}{\pi \cdot D(m)} \qquad \text{(Eq. 6.3)}$$

With all the equations mentioned above it will be down below displayed the value of each speed.

	Ribbon	Roving
V_{in} *(m/min)*	0,667	2
V_{mdl} *(m/min)*	1	3
V_{out} *(m/min)*	100	100
W_{in} *(rpm)*	7,0736	21,221
W_{mdl} *(rpm)*	10,6103	31,831
W_{out} *(rpm)*	1061,033	1061,033

Table 6.2 *Linear and rotational speeds values.*

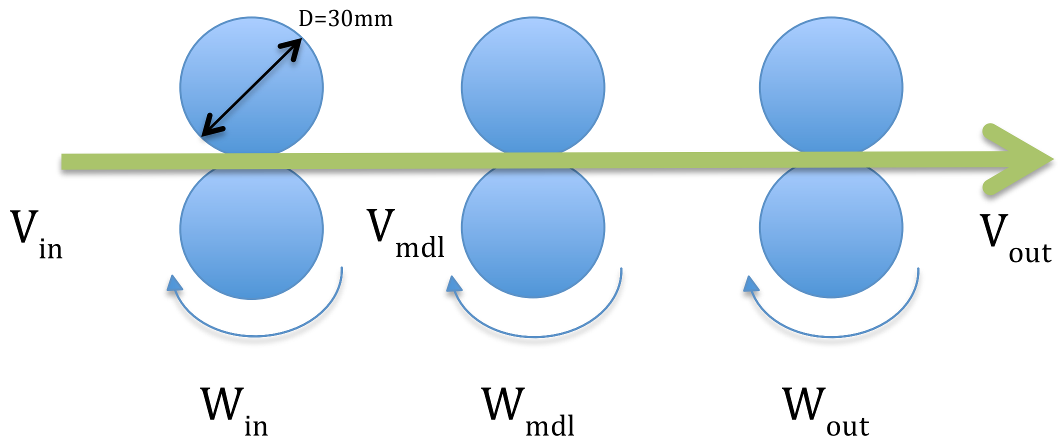

Figure 6.1 *Section of the drafting unit.*

6.1.1 Alternative 1

The first alternative taken into account in order to develop the drafting system is to command the variations of rotation speeds with mechanical transmissions.

In order to change the distances between the rollers, and therefore, treat different types of fibres, the drafting roller will be able to slide on a guideway.

These types of mechanisms are used in industrial machines and thus, it is interesting to see if they are suitable for the prototype.

In this particular alternative, only one engine is needed. Therefore, to amortize the economics, the engine that could be used could be the one from *Schneider Electrics*® that is already at the university (BSH0551P01A2A). The brushless technology of this engine and its characteristics make it suitable for this prototype.

This particular motor (see all the properties at the annex) turns at a nominal rotational speed of 8000rpm. As explained before, the maximum rotation speed is the one concerning the last cylinder of the drafting unit, which, within the example, ranges in values close to 1000rpm. To achieve this rotational speed at the last cylinder with an engine of these characteristics it is needed to include a reducer (GBX060008K) and also a drive (LXM32AU60N4 or LXM32MU60N4). The reducer and the drive are also from *Schneider Electrics*® according to the compatibilities of the engine.

As known, reducing the rotation speed provokes an augment in the engine torque. When decreasing the rotation without slowing down the engine, the force generated is increased. The purpose of a speed reducer is not just to increase torque, but to reach the ideal torque for the machine in use.

Once the last cylinder speed is achieved, the two remaining speeds will be commanded, as mentioned, by mechanical transmissions, specifically with gears. Lots of combinations of gears can be used in order to achieve the reduction of speed we are looking for. Following, it is shown the combination of gears which is thought to be the most suitable:

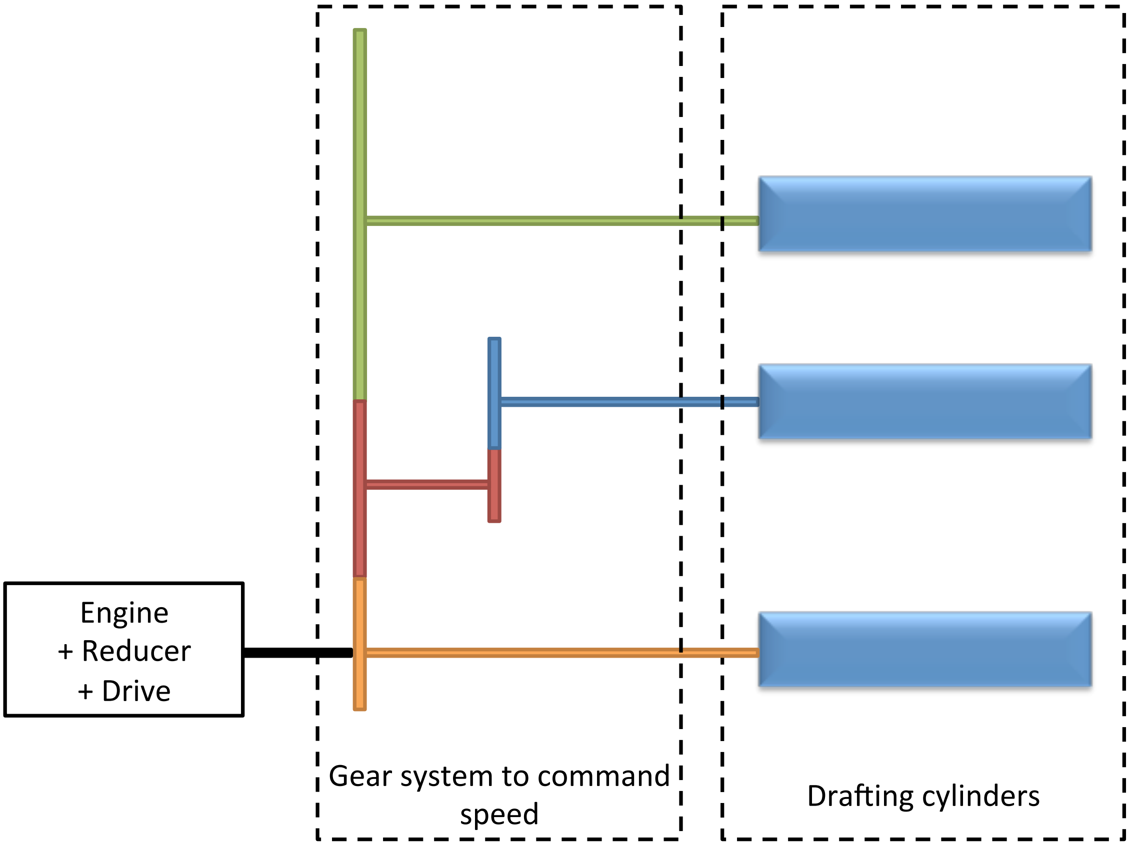

Figure 6.2 *Combination of gears between drafting rollers.*

The reason why it is thought that this combination would be the most suitable is because it contains the less number of gears to make all the cylinders rotate in the same direction. In other words, less space is needed, which makes the drafting system handier. Of course, the diagram shown above is only an approximation of what the gear system would look like. If this alternative would be chosen, it would be necessary to discuss about the number of tooth each gear should have and also about their radius.

The advantages of this alternative are the outrageous number of possible gears combinations. We can use several different gears with different tooth numbers and radius. Furthermore, we could use standard market gears or even try to create our own gears with a 3D printer. However, creating 3D printed gears can be not useful in account of the weakness of the materials used nowadays in this technology.

Another positive point is the fact that only one engine is needed and therefore, it is not needed to synchronize it with other engines. Moreover, the presence of gears makes the machine very robust, as it obliges to maintain the distances between the pair of rollers.

Nonetheless, there are also some disadvantages. Using mechanical transmissions will not allow altering easily from long fibres to short fibres because changing distances between the drafting cylinders will have to deal with removing the gears involved with others more suitable. That is to say, to change the gears for others with more or less radius. Moreover, the speeds relation between the cylinders also varies depending if the yarn is made from ribbon or roving. That fact will cause again a need of changing the gears so that they conform to the new relations and that would take more time and also more gears and calculations. At last, including mechanical transmissions to the drafting unit will make it heavier and more voluminous.

6.1.2 Alternative 2

This proposal consists of three independent motors that will control the speed of each pair of rollers. As in the first alternative, the rollers will be able to slide on a guideway in order to treat different types of fibres.

The engines chosen for this alternative will be the same as the one mentioned in the first alternative, due to the accessibility had to them. The three engines will have a nominal rotational speed of 8000rpm and with the presence of a drive and a reducer the desired speed will be achieved. Each pair of roller will have a different reducer, as the speed needed changes between them.

The fact that the movement of each pair of roller is carried out by a different engine involves that the speeds of the pairs of rollers are not physically related.

Thereby, it will be easier to change the distance between the rollers in order to treat different lengths of fibres, as in the first alterative it was necessary to bear in mind the gears relations. However, this can cause problems if the synchronization of the three engines is not well done.

Unlike the first proposal, changing the speeds of the rollers will be easily done with the drive and so, it will not be necessary to use gears. For this reason, the time employed will be reduced.

The mechanism responsible of transmitting the rotation speed will be driven by a computer. Thanks to the numerical control, the desired speed will be introduced on the computer and the rollers will then change their rotational speed.

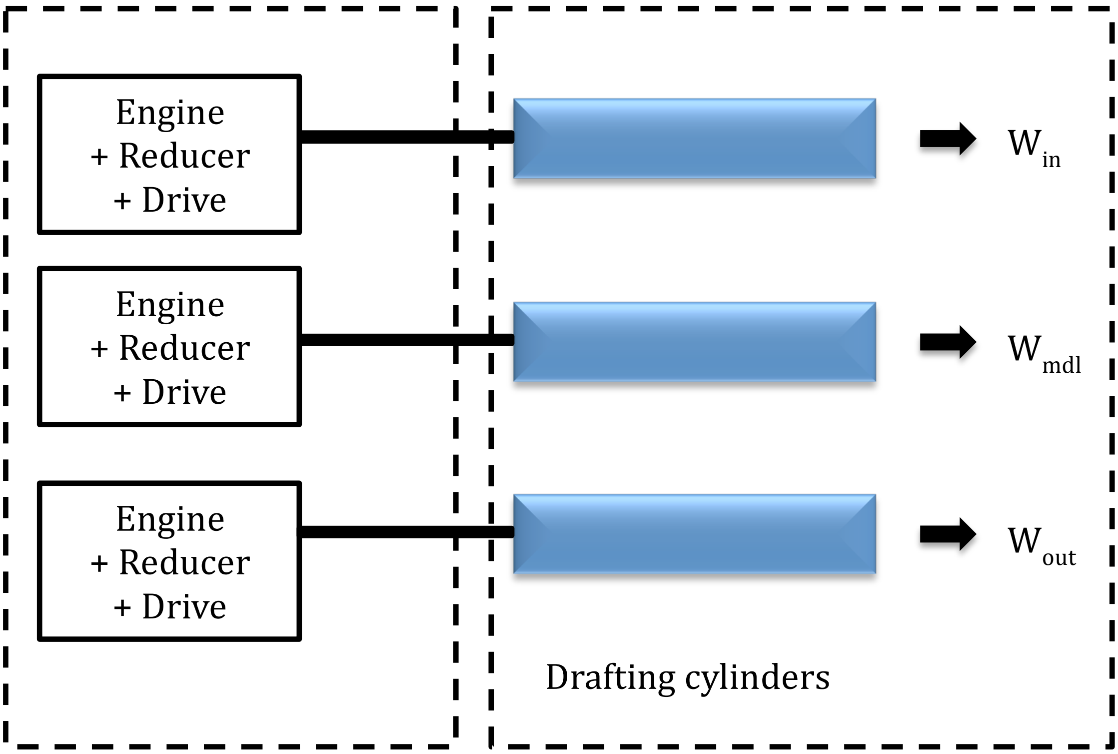

Figure 6.3 *Engines distribution*

6.1.3 Alternative 3

In case it is not possible to obtain a drafting unit with variable distances between the rollers, the two alternatives above could not be used to spin both long and short fibres. To resolve this problem, a third alternative is proposed. More than an alternative, it is an implementation applicable to both of the previous two proposals.

That implementation consists of acquiring two different drafting arrangements instead of only one. Each of those two drafting units will have an individual purpose: one will be used to spin short fibres and the other will be used for long fibres.

The problem that presents this alternative appears when trying to give the speed to the rollers of both drafting arrangements.

The simplest way to do so would be to treat both drafting units per separate, that is to say, to make them function with any of the two alternatives mentioned before but with no correlation between them. But, in order to economize, it is better to see if there is a way to connect both drafting arrangements with only one *rotation system*.

To achieve this aim, a research has been done and it has been found that the best way to relate both drafting arrangements is with the system called universal joint or Cardan joint, which allows joining two non-collinear axes. Its objective is to transmit the rotational movement of a shaft to the other despite the non-co-linearity. The main problem that appears with this joint is that, by its configuration, the shaft at which it is given the transmission does not rotate with a constant speed. However, if two Cardan joints are placed in series and the first shaft and the last one are parallel, these differences in rotation speed are cancelled and both the last and the first shafts rotate at a regular and equal speed. Thanks to the parallelism of the rollers from both drafting units, this particular concept is the most suitable to be applied in order to relate the rotation speeds of both drafting units by only the use of one *rotation system*.

Following, a scheme of this mechanism is shown:

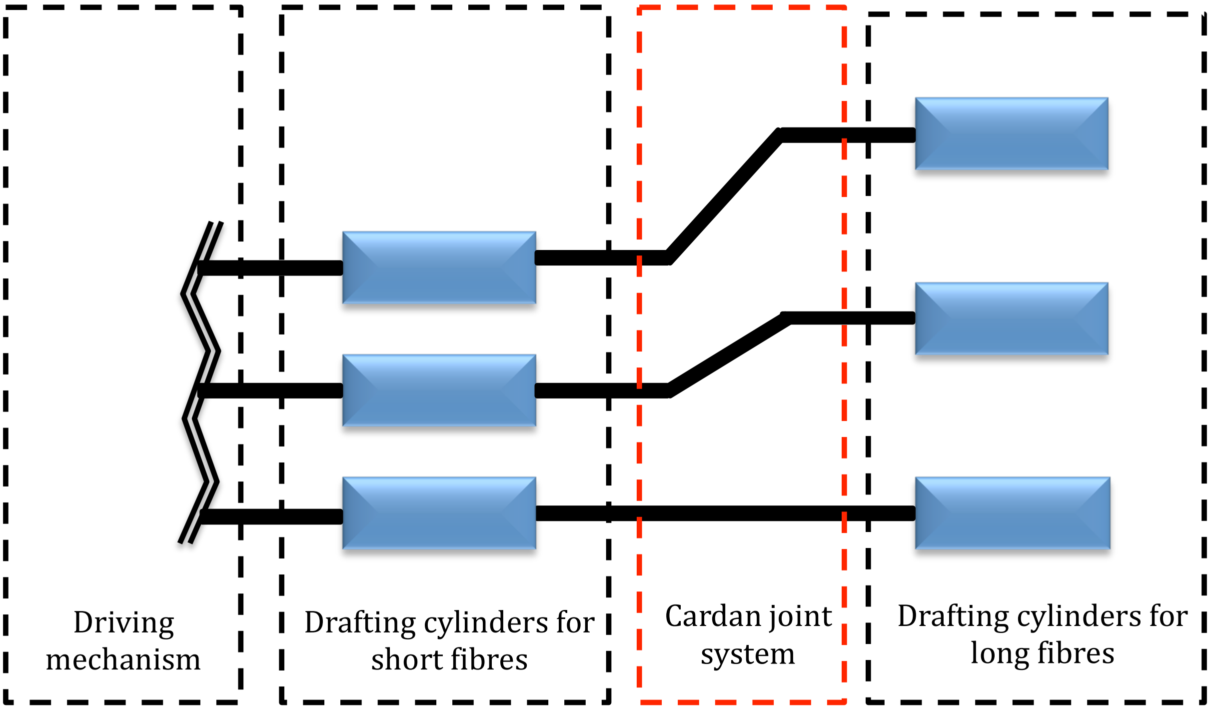

Figure 1 *Union between drafting systems by a cardan joint.*

As the scheme shows, only two Cardan joints mechanisms are needed because the lasts cylinders will be collinear.

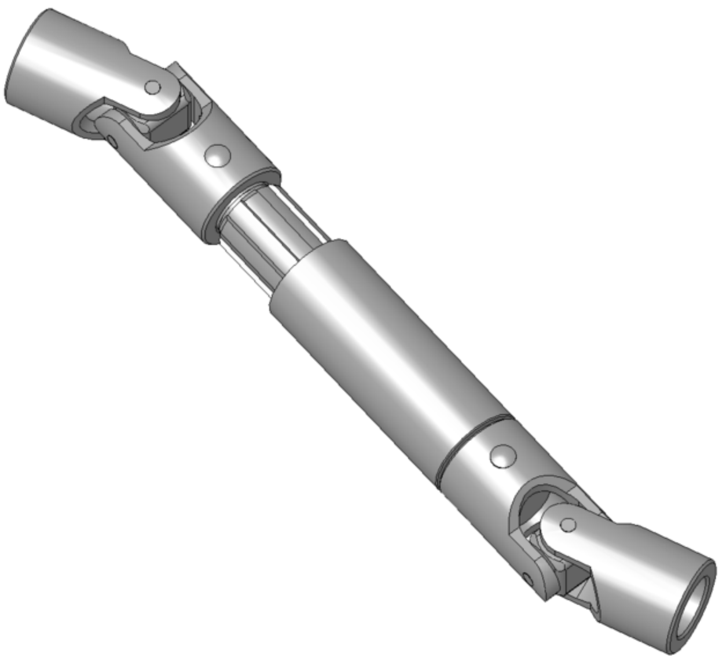

Figure 6.5 *Example of two Cardan joints.*

This implementation could have two possible hollow spindle structures. The first one consists on having only one hollow spindle and a wrapping unit structures, and therefore, long and short fibres are not going to be spin at the same time. In order to make it possible, a rail system will enable changing the hollow spindle from spinning long fibres to spinning short fibres.

On the other hand, the other alternative consists on having two different hollow spindles, one for treating long fibres and the other for short fibres. There will also be two storages units, as if desired the yarn could simultaneously be done from the two types of fibres.

In both occasions, the two drafting units will be functioning at the same time even though, if wanted, only one of them will be used to spin. From an energetic point of view, that implementation would not be considered as suitable when producing only one yarn, because it implies a loss of energy. That is completely true, but it has to be reminded that it is a prototype what is being tried to achieve, and not a fully operable industrial machine. That is the reason why that energy loss does not include any impediment.

Once the ribbon or the roving has been treated in the drafting system it is now time to create the wrap yarn. This step of the machine will be done by the hollow spindle or also known as wrapping unit. This part of the prototype will characterize the machine, as the aim of the project is to produce a wrapped yarn.

6.2 HOLLOW SPINDLE OR WRAPPING UNIT

As we have been discussing throughout the project, the aim of it is to achieve those wrap yarns wanted.

According to that, the ribbon or the roving coming from the drafting unit would have to be wrapped by a filament. That filament will be stored around a bobbin (on the hollow spindle) and, as the fibre strand passes through the centre of that bobbin, the filament will wrap it thanks to the rotation speed given to the bobbin.

In general terms, combining the rotation speed of the bobbin with the vertical speed of the fibre strand will be the key of the wrapping yarn. More rotation speed with less vertical speed will produce a much wrapped yarn and vice versa. In order to measure if the yarn is more or less wrapped the next formula will be applied:

$$Amount\ of\ wrapping = \frac{W_{bobbin}}{V_{out}} \left[\frac{rev\ of\ bobbin}{m\ of\ yarn}\right] \quad \text{(Eq. 6.4)}$$

For the purpose of giving a certain rotation speed to the bobbin, another engine is needed. Again, the engine that is already at the University is suitable for this purpose. But, as mentioned before, when looking for a much wrapped yarn, it is more convenient to accomplish a high bobbin rotation speed. As the engine provides a speed of 8000rpm it would be suitable to include to the prototype a system to augment and vary that speed. To obtain this augmentation of speed, a gears system can be used. This system should be as simple as possible. That is why, only two or three teeth wheels, depending on the number of drafting units, will be used.

In order to make the prototype as much trustworthy to the existent machines, those gears will be not directly physically connected but connected by a toothed belt. The fact of connecting both teeth wheels with a belt also contributes to an ease to vary the speed by changing those gears and a diminution of lubrication to the system.

According to the following equation, whatever desired rotation speed of the hollow spindle can be obtained depending on the teeth of the gears:

$$W_{engine}Z_{engine} = W_{hollow\ spindle}Z_{hollow\ spindle} \quad \text{(Eq. 6.5)}$$

where:

W=rotational speed (rpm)

Z=number of teeth of the gear

The number of teeth of the gears of the equation above can be replaced by the gear radios, as their dimensions are directly proportional.

Aside these two or three gears, depending on the number of hollow spindles, more gears will be incorporated to pause the machine whenever required. This is useful because if an unforeseen takes place the hollow spindle can be quickly stopped without reducing the engine speed.

The hollow spindle may be paused thanks to the presence of two gears (*contact gears*) that if desired will stop making pressure on the dented belt with the aim that the belt does not make contact with the hollow spindle gear. This stopping device will be assisted by a break that will make contact with the gear of the hollow spindle if activated.

The number of additional gears used will depend on the design of the drafting unit. As it has been said, each hollow spindle will have two contact gears.

It is important to remark that, in order to let the yarn pass through the gear attached to the bobbin, this one has to contain a hole on its centre.

To make all this explanation more visual, it is shown a scheme of how the mechanism would work in case there would be two different hollow spindles.

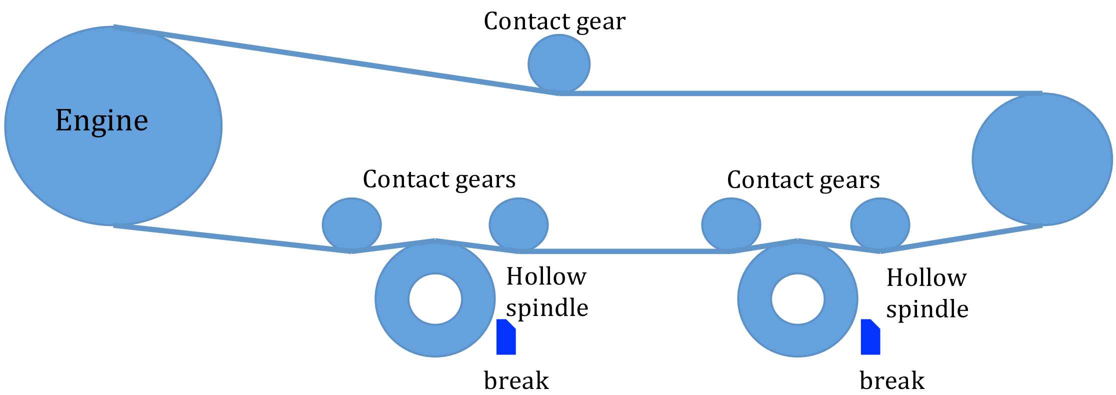

Figure 6.6 *Diagram of the gears and the stopping mechanism.*

Each pair of contact gears is placed in the inner part of the machine. This way, if it is necessary to repair some part of the hollow spindle the dented belt does not interfere

6.2.1 Calculation of the dimensions

Hereafter, it will be displayed an example of parameters values in order to show a possible configuration of the prototype.

For instance, if the following speeds are imposed:

V_{out} = 100 m/min
W_{engine} = 8000 rpm
$W_{hollow\ spindle}$ = 35000 rpm

Table 6.3 *Speed values*

The amount of wrapping obtained will be of:

$$wrapping = \frac{W_{hollow\ spinde}}{V_{out}} = \frac{35000}{100} = 350\ {}^{rev\ of\ bobbin}/_{m\ of\ yarn} \qquad \text{(Eq. 6.6)}$$

For obtaining the pitch, the distance between each yarn tour, it is necessary to do the next conversion:

$$pitch = \frac{1}{350}\frac{meter}{rev\ of\ bobbin} \cdot \frac{1000\ mm}{1\ meter} = 2{,}86\ mm \qquad \text{(Eq. 6.7)}$$

Therefore, between each tour of filament there will be 2,86mm of separation.

Considering the *equation 6.8* showed above:

$$Z_{engine} = \frac{W_{hollow\ spindle}}{W_{engine}} \cdot Z_{hollow\ spindle} = \frac{35000\ rpm}{8000\ rpm} \cdot Z_{hollow\ spindle} \qquad \text{(Eq. 6.8)}$$

$$Z_{engine} = 4{,}375 \cdot Z_{hollow\ spindle} \qquad \text{(Eq. 6.9)}$$

The next table will show the dimensions of the engine gear radios for different values of the hollow spindle gear.

Radius of the hollow spindle gear (cm)	Radius of the engine gear (cm)
2	8,75
2,5	10,9375
3	13,125
3,5	15,3125
4	17,5
4,5	19,6875
5	21,875
5,5	24,0625
6	26,25
6,5	28,4375
7	30,625
7,5	32,8125
8	35
8,5	37,1875
9	39,375
9,5	41,5625
10	43,75
10,5	45,9375

Table 6.4 *Gear dimensions*

As it can be seen in the *equation 6.9* and in the *table 6.4*, when the gear radius of the hollow spindle increases the gear of the engine increases too.

6.2.2 False twist element

As commented along the pages before, some short fibres present difficulties when treated. In order to overcome those difficulties, providing a false-twist is a must. As explained in the annex, applying a false-twist to fibres gives them a stable torsion in the upper side, which will help its treatment. Therefore, the wrapping unit will have to contain some sort of false-twist mechanism. In addition, the false-twist applied is not contradictorily with long fibres so, it will be suitable for both long and short fibres.

When applying the false-twist two alternatives can be discussed: false-twist applied above or below the bobbin of the hollow spindle. But, the closer to the end of the drafting unit will occur the false-twist, the better is. In order to give the appropriate time to make the false torsion disappear before storing the finished yarn, it is preferred to apply the false-twist above the bobbin.

Once decided that it is better to place the false-twist above the bobbin, it is time to determine how it is going to be applied. Hereafter, three possibilities are presented:

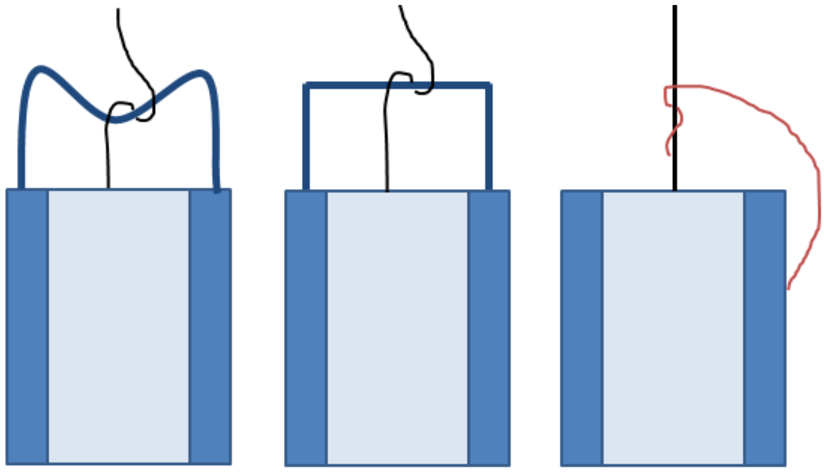

Figure 6.7 *Design of three false twist devices.*

As it can be seen in the next chapter of the project (*visit to enterprises*) those three possibilities shown above are quite similar to the ones used in real enterprises.

After all, and as a conclusion, even though deciding that the best option is to place the twisting element at the top of the bobbin, the optimum alternative is to have a removable twisting element. This way it will be possible to attach or remove the twisting element depending on the fibres requirements. If the fibres treated need a false-twist, the false-twist element will be attached to the bobbin. Whereas, if the fibres treated do not request any false-twist principle it will be possible to remove it and treat them without a twisting element.

6.3 STORAGE UNIT

Once the wrap yarn has been produced it is now time to storing it. When the yarn leaves the hollow spindle it passes around a metallic bar. This device increases the path of the yarn before being stored. Through this section the use of the metallic bar will be specified.

The common way of storing the yarn is wrapping it around a bobbin. Hereafter, two different processes will be explained.

6.3.1 Alternative 1

This proposal mainly consists on a rail cylinder and a bobbin. When the yarn passes around the metallic bar, is then introduced into the rails of the cylinder thanks to the rotation of it. This movement is carried out by the engine of the drafting system that transmits its rotation to the railed cylinder with a dentate belt. The fact that the yarn has to have the same speed during the process, otherwise it would break, makes possible the use of the motor of the drafting system. Moreover, there is not an expense on buying another engine.

The yarn introduced in the cylinder rails is not storage on it. Attached to the railed bobbin, there is a smooth bobbin where the yarn is wrapped along it in a distributed way, thanks to the rail cylinder that places the yarn each turn in a different place. Once the first layer of yarn around the smooth bobbin is finished the next layer is started and so on. The smooth bobbin also turns around its axis thanks to friction between the bobbin and the cylinder.

What makes essential the use of both bobbins is the fact that when wrapping the yarn around the bobbin the diameter of it increases with the layers. Nevertheless, the production speed desired at all times is constant. So if the yarn would be directly wrapped around the smooth bobbin the rotational speed of it would have to decrease continuously.

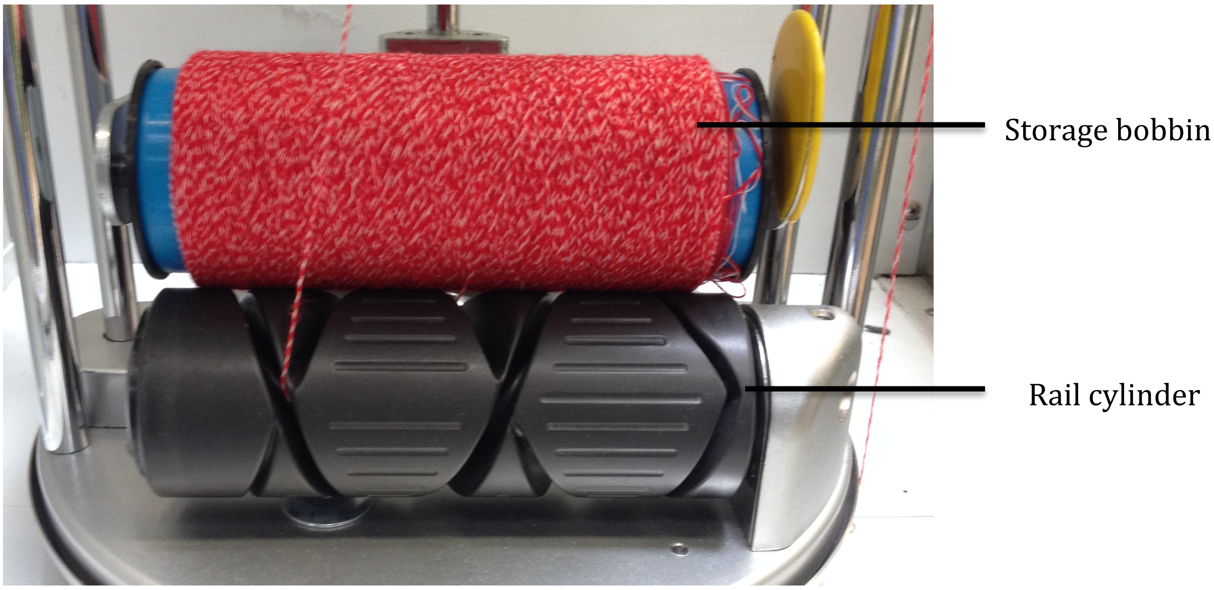

Figure 6.8 *Storage system (rail and smooth bobbin)*

Moreover, it is important to underline that when the yarn enters into the rail it experiments a new speed (v_{axial}), a part from the one that existed already ($v_{tangential}$). The axial speed arises from the fact that the yarn travels horizontally through the rail of the cylinder.

In the next picture the two speeds will be showed.

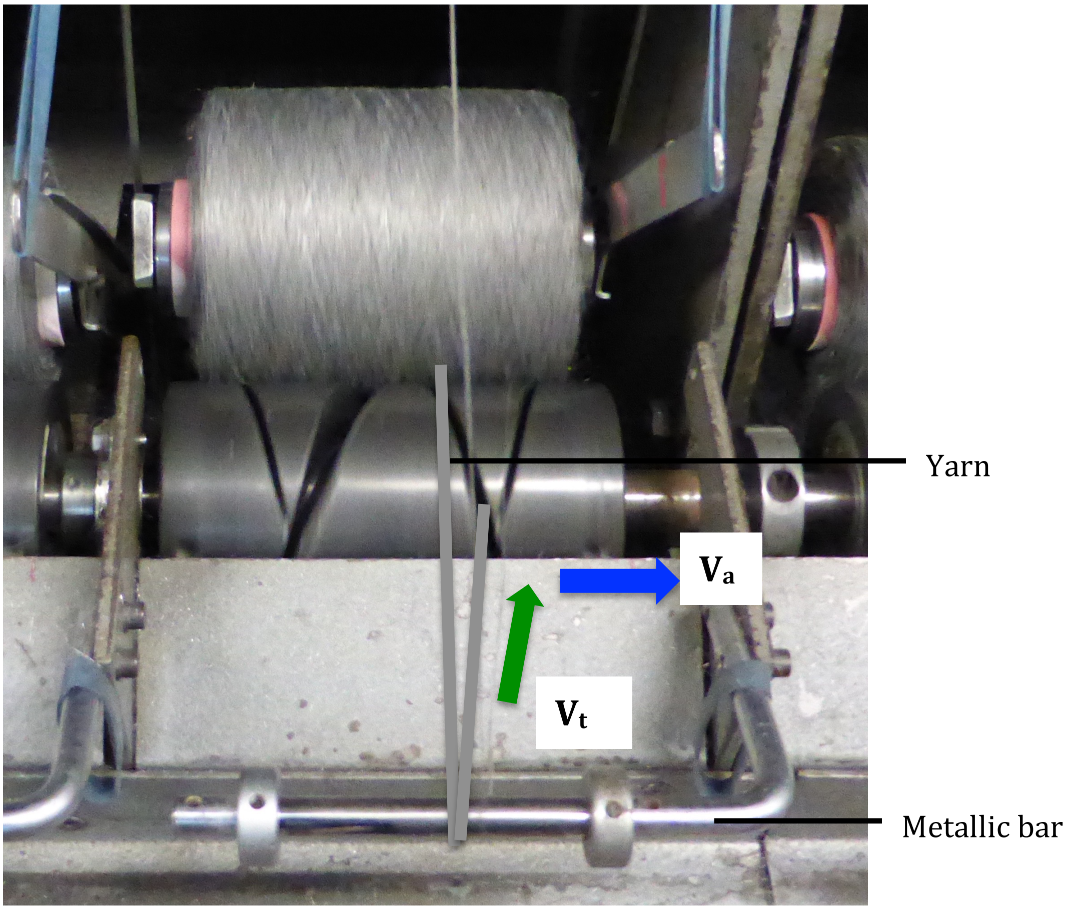

Figure 6.9 *Yarn speeds.*

$$V_{yarn} = \sqrt{V_t^2 + V_a^2} \qquad \text{(Eq. 6.10)}$$

$$V_t = \pi \cdot D_c \cdot n_c = \pi \cdot D_b \cdot n_b \qquad \text{(Eq. 6.11)}$$

$$V_a = pitch \cdot n_c \qquad \text{(Eq. 6.12)}$$

With the aim of wrapping the yarn around the bobbin properly and without being broken it is necessary to have the same yarn speed during its production, and also during its storage. That is why, the speed of the yarn in the storage process (V_{yarn} from *equation 6.10*), has to be equal to the output speed of the drafting unit V_{out}=100m/min, from *table 6.3*.

This way,

$$V_{yarn} = V_{out} = 100m/min, \qquad \text{(Eq. 6.13)}$$

and the only possibility is to obtain a rotational speed (n_c) that complies with:

$$n_c = \sqrt{\frac{V_{yarn}{}^2}{\pi^2 \cdot D_C{}^2 + pitch^2}} \qquad \text{(Eq. 6.14)}$$

The diameter of the cylinder and the pitch of the cylinder will be always constant.

As it has been said, before being wrapped on the storage bobbin the yarn goes around a metallic bar. The principal aim of the metallic bar is to increase the path of the yarn before being stored, this way the tension of the yarn will decrease.

In the next picture there will be displayed the different configurations that the yarn can adopt while going through the rail.

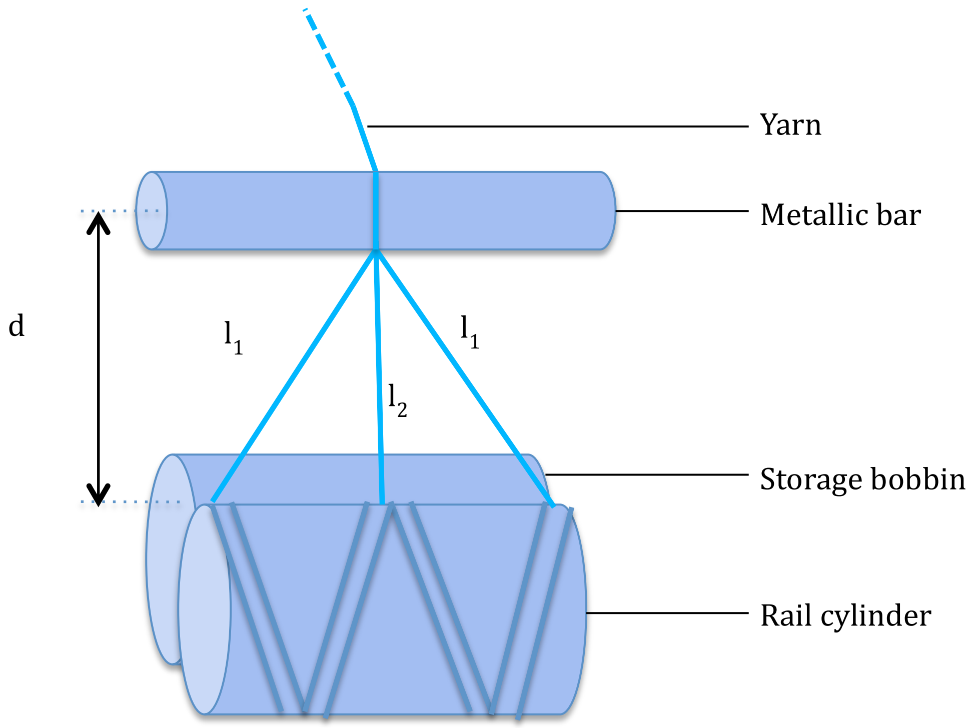

Figure 6.10 *Storage unit.*

When the yarn presents the position represented by l_2 it experiments the highest tension, as the way before getting in touch with the cylinder is the maximum. Whereas, when the yarn is in the middle of the rail cylinder, l_1 position, the tension is the minimum. The next equation shows the relation between the yarn positions and tension variation.

$$Yarn\ tension\ variation = \frac{l_2 - l_1}{l_1} \cdot E_{young} \qquad \text{(Eq. 6.15)}$$

If increasing the *d* value, l_1 and l_2 become more similar and the tension variation of the yarn decreases as shown in the *equation 6.15*.

In addition to the purpose explained, the metallic bar also helps the yarn being introduced into the rails. So, if the bar was not used the yarn could escape from its place.

6.3.2 Alternative 2

Following with the idea that when wrapping the yarn around the bobbin the diameter increases and thus it cannot be directly done, in this alternative the function of the railed cylinder will be replaced by a smooth bobbin and a guide. This bobbin will receive the rotational movement from the motor of the drafting system with the aid of a dentate belt. The other bobbin will be moved thanks to the friction between both bobbins, moreover, is in this bobbin where the yarn will be stored.

Once the yarn leaves the hollow spindle, it passes around the metallic bar and then through a guide, which is charged of distributing the yarn along the bobbin by moving horizontally from one side to the other. So, when one layer is completed the next one will be started.

In this alternative, the fact that the speed of the yarn has to be constant through all the stages will be easily achieved with the aid of the guide. Thus, the speed guide will be variable and programmable with a control system.

Unlike the method of the rail cylinder, for obtaining the yarn speed of 100 m/min it will not be necessary to focus on the rotational speed of the smooth bobbin. Only with the guide, whose speed is V_a, it will be possible to obtain the desired speed V_{yarn}.

The metallic bar, in this alternative, will continue having the same purpose of reducing the tensions.

Figure 6.11 *Storage system (2 smooth bobbins and a guide).*

7. VISIT TO ENTERPRISES

The 29th April of 2015 two factories where visited in order to get to know all the details of wrap yarn machines. All of them where industrial machines, as the production of the factories are of a large scale. However, the examination of the different machines will be profitable for the design of the prototype, as the characteristics of both machines are the same.

7.1 SHAPPE TECHNIQUES

8 Rue Alsace
88520 Croix aux Mines - France

The first company visited was *Shappe Technique*, situated in Alsace and established in the late XIXth century. It produces the latest generation of advanced technical fibres designed to fulfil the highest requirements in a large number of industrial fields.

The machine that could be analysed was the *ParafiL* created by *Suessen*. At the moment of the visit the machine was producing a yarn of metallic fibres.

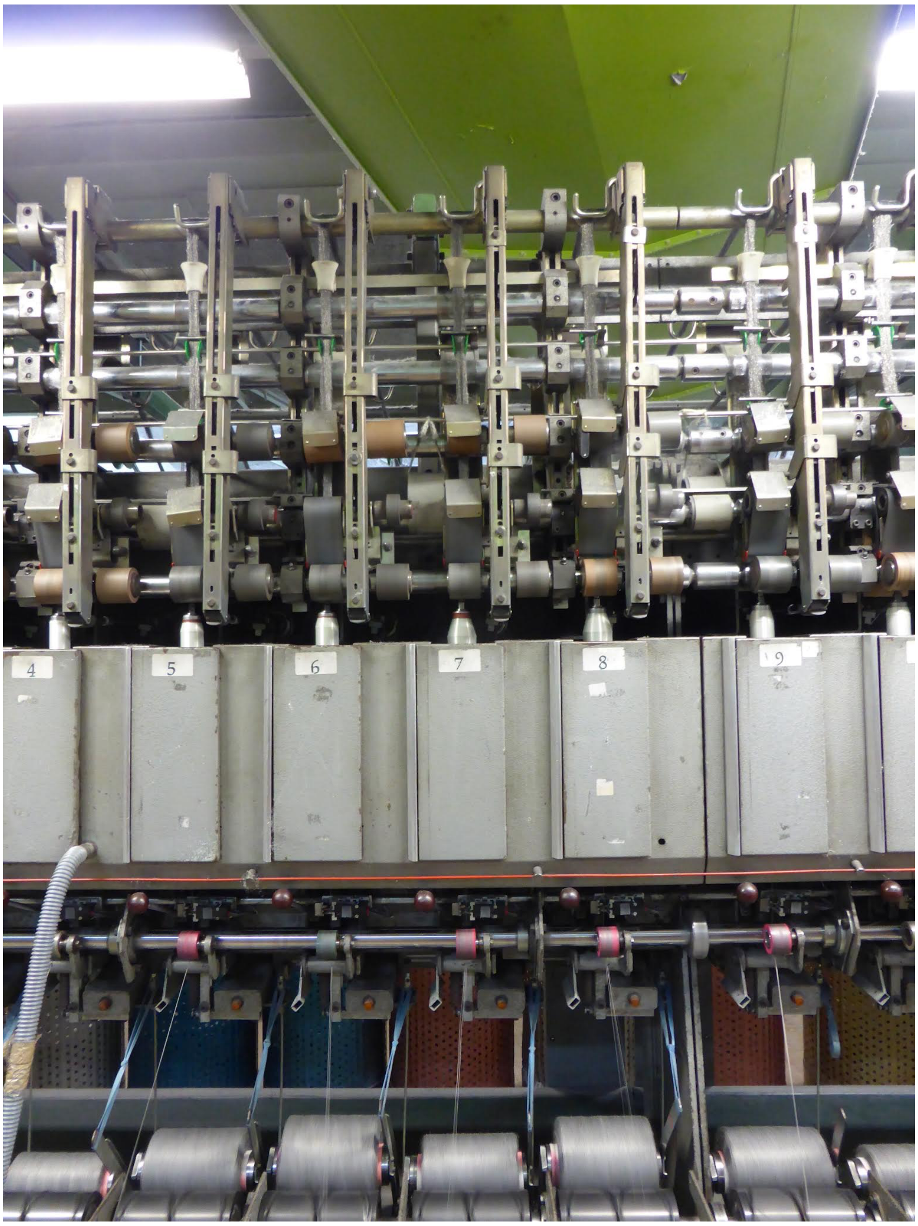

Figure 7.1 *General view of ParafiL machine by Suessen*

In the photograph shown above it can be seen the ParafiL machine by Suessen. The upper half part of the picture corresponds to the drafting system. Below it there is the hollow spindle, that in this case it is covered, and on the bottom of the picture it is placed the storage unit.

The next picture shows the drafting unit in more detail.

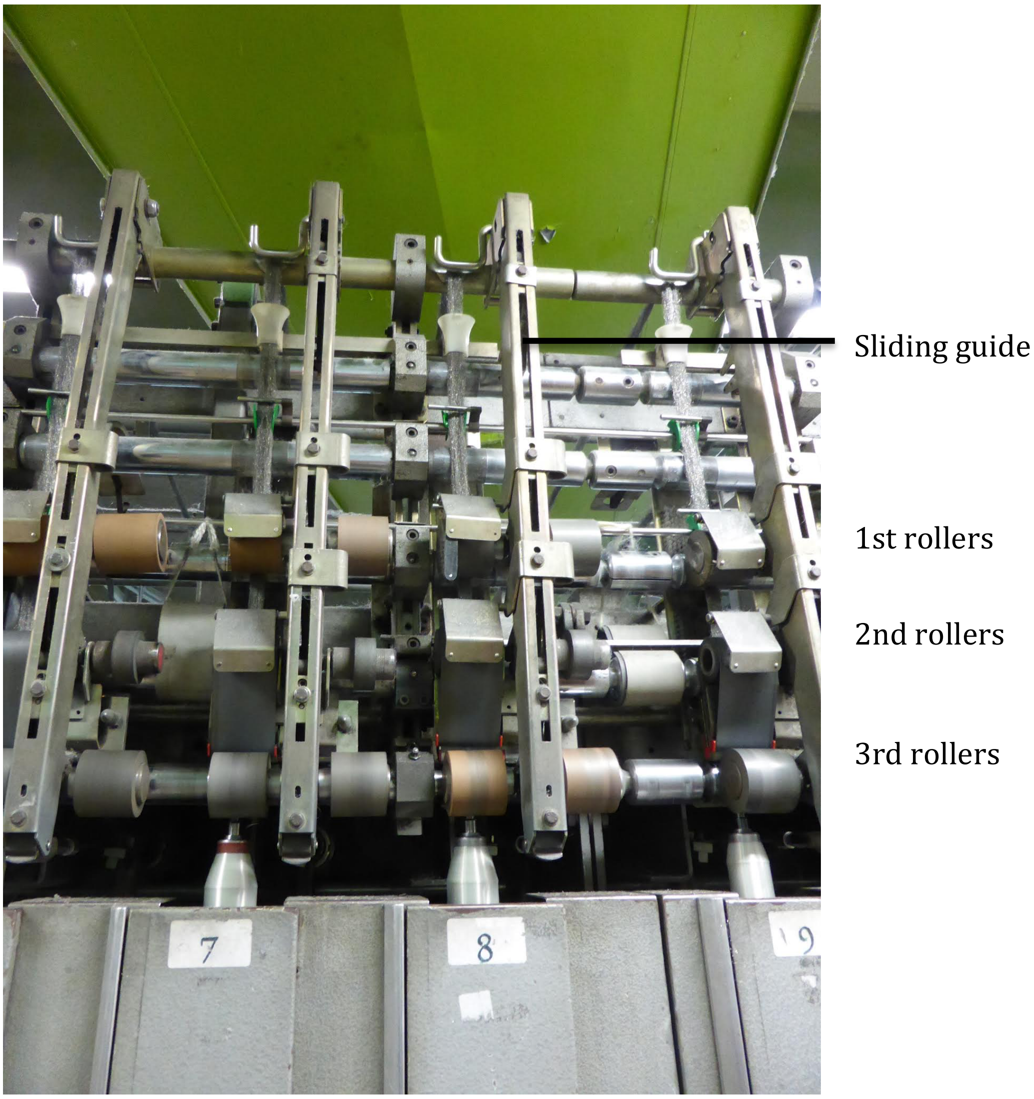

Figure 7.2 *Drafting system.*

The drafting system of this machine is composed by three pair of rollers. What characterizes this unit is the capability of changing the distance between the first and the second pair of rollers. This characteristic permits working with different types of length fibres. This idea will be taken into account in the design of the prototype as one of the objectives is treating both short and long fibres. The distance can be changed by the presence of sliding guides that permits moving up and down the drafting rollers.

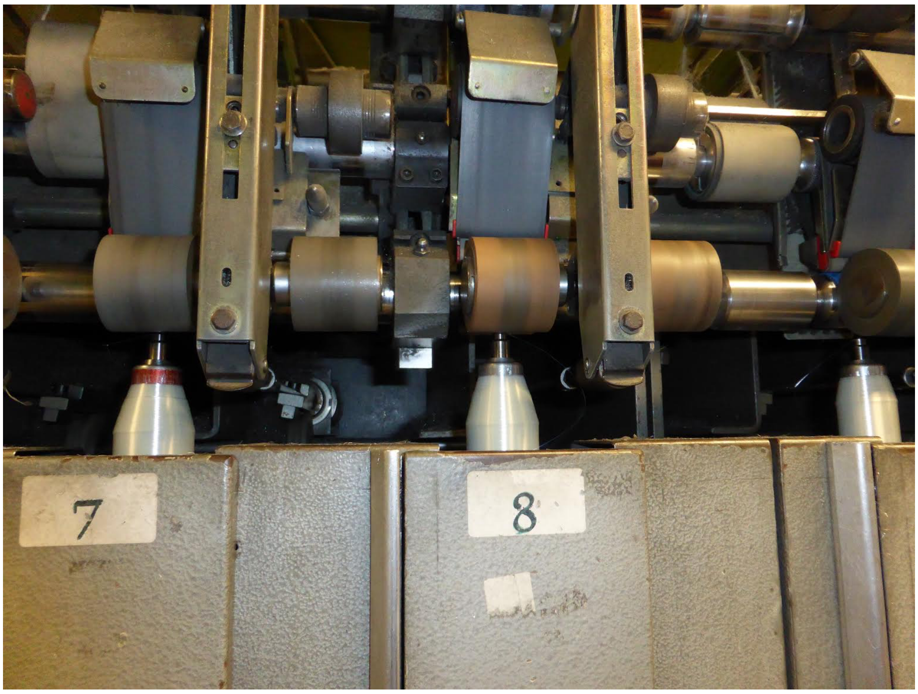

Figure 7.3 *End of drafting and start of hollow spindle.*

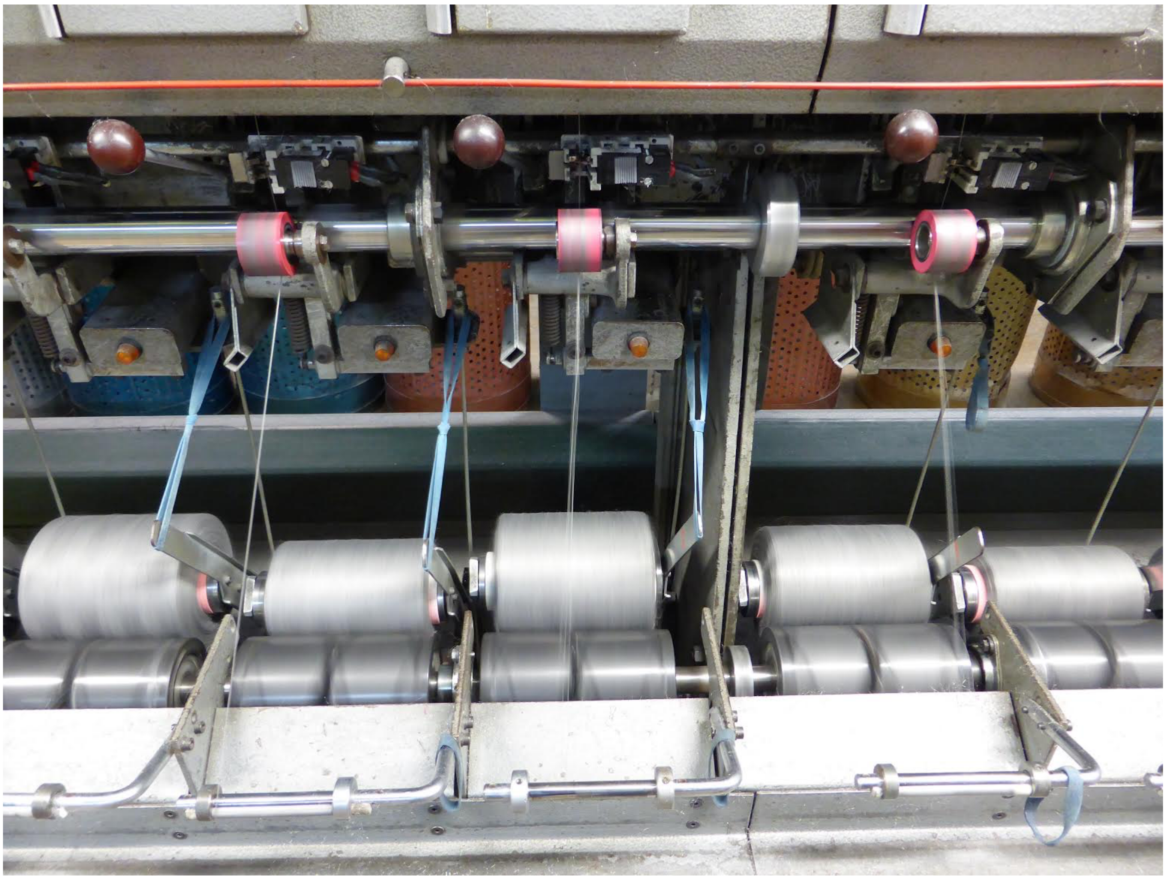

Figure 7.4 *End of hollow spindle and storage unit.*

It is important to emphasize the fact that this machine, in particular, does not have the possibility of making a false twist on the yarn. As it can be seen in the two pictures above, nor on the top of the hollow spindle nor on the bottom, there is the device charged of introducing a twist on the yarn. This is because all the yarns produced in this machine do not need this characteristic. For example, the metallic yarn, that was being produced the day of the visit, is robust itself and does not need an extra treatment.

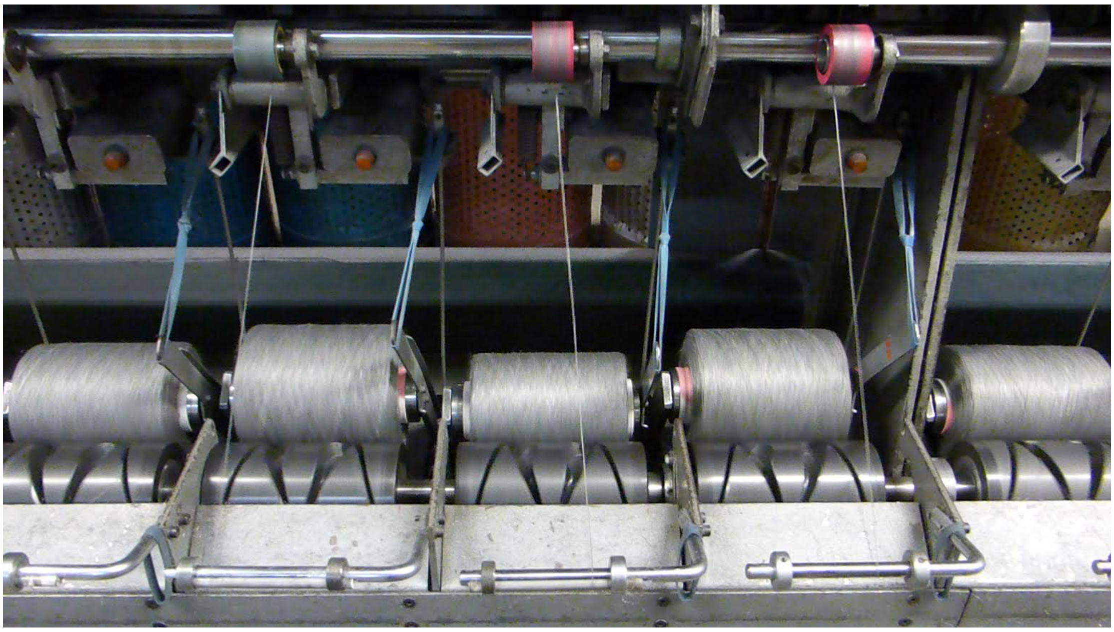

Figure 7.5 *Storage system*

Last but not least the storage unit takes place. As it has been explained on the prototype chapter, the storage unit can be of two different types, and this is the one that consists of a rail cylinder and a smooth bobbin.

Due to the confidentiality protocol followed by the company no more information could be obtained about this machine. However, the enterprise had the courtesy to offer a system of false twist for the *Université d'Haute Alsace.*

7.2 BERGÈRE DE FRANCE SA

91 Rue Ernest Bradfer
55000 Bar-le-Duc – France

Bergère de France is a company created in 1946 and situated in the region of Lorraine. It is highly known by its production of yarn knitting. In this factory the yarn is made in its entirety.

Several machines, from *Allma Saurer* Brand, charged of creating wrap yarn were observed. All of them were formed by the three parts explained in the prototype chapter: the drafting unit, the hollow spindle and the storage unit. However, each one had a specific characteristic that made it different from the rest.

The first machine had the storage unit above the drafting unit and the hollow spindle. In this way, the path since the yarn leaves the hollow spindle until it arrives to the storage unit increases strikingly. This aspect permits reducing the length difference that the yarn experiments when going from one side to the other of the rail bobbin.

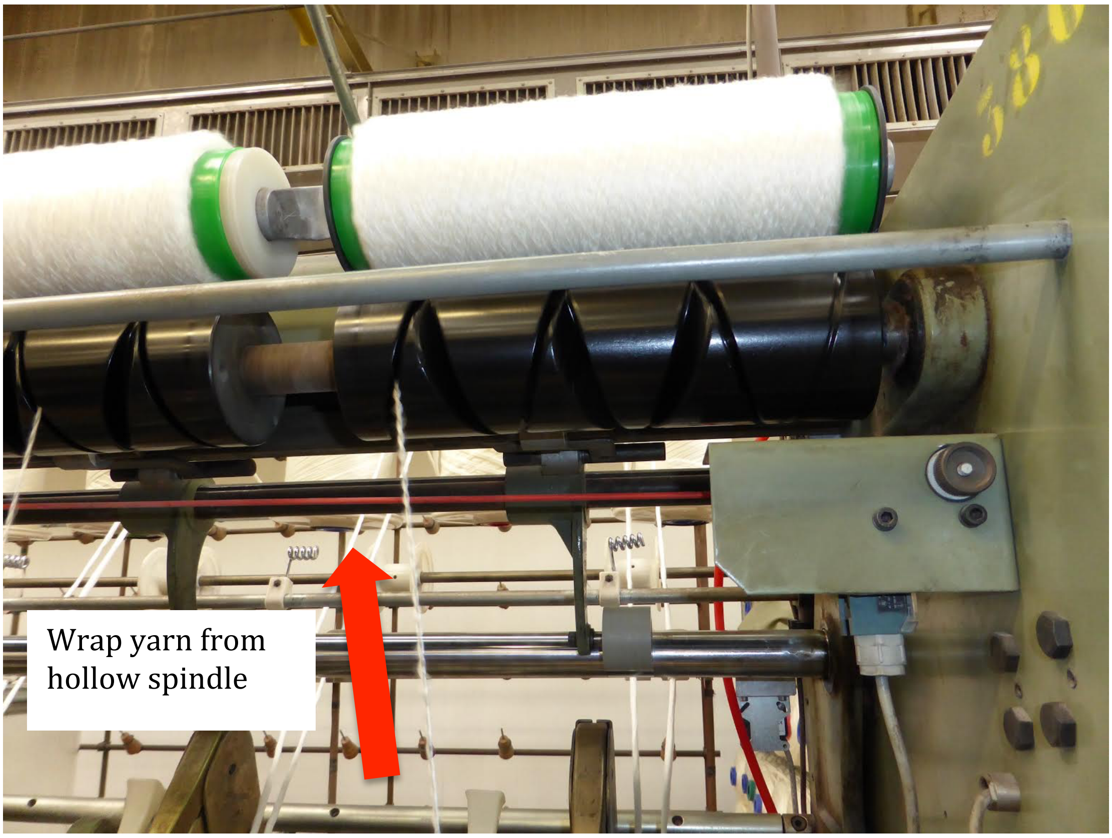

Figure 7.6 *Storage unit situated on the top of the machine.*

As it can be seen in *figure 7.5* the yarn arrives to the storage unit from below. Once more, the storage unit consists, as in the first factory visited, on a rail bobbin charged of distributing the yarn on the smooth bobbin.

In reference to the second machine observed, what makes it special is its control system. All the actions of the machine are commanded by a computer, the parameters are introduced through a screen and analysed by an automatic control. Moreover, if the machine detects an anomaly in the process, the production is interrupted. The control system searches the localization of the anomaly and the result is printed on the screen. In order to reinitiate the process the presence of a mechanic is required for repairing the failure.

Focusing now on the third machine, the wrap yarn produced is characterized by the presence of two different filaments on the centre of the yarn. In order to make it possible, it is necessary to incorporate a second drafting system. So, each unit will be responsible of treating one filament and afterwards they will be mixed before arriving to the hollow spindle where the wrap yarn will be done. The possibility of making this type of yarn it has not been taken into account when designing the prototype, as this type of yarn is very specific.

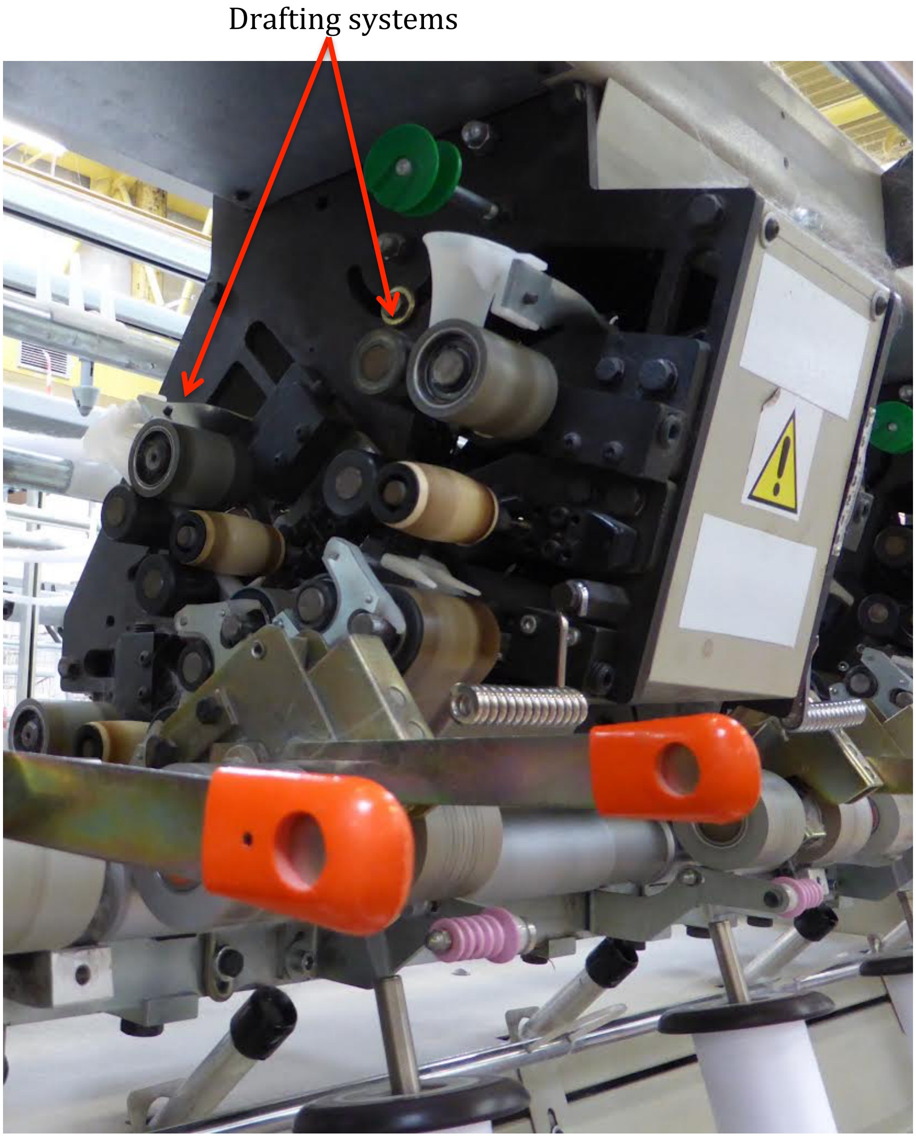

Figure 7.7 *Machine with two drafting systems.*

Last but not least it would be interesting to comment the fact that all the machines observed in this factory, in contrast to *Schappe Techniques*, included the device for introducing a false twist to the yarn. Moreover, the false twister was placed after the hollow spindle unlike the proposition made in the chapter of the prototype. This is due to the fact that the machines observed where for an industrial use and their dimensions are bigger than a prototype. Considering that, when introducing a false twist to a yarn it is necessary to leave a space until it is stored in the bobbin in order to get rid of the tensions produced by the false twist.

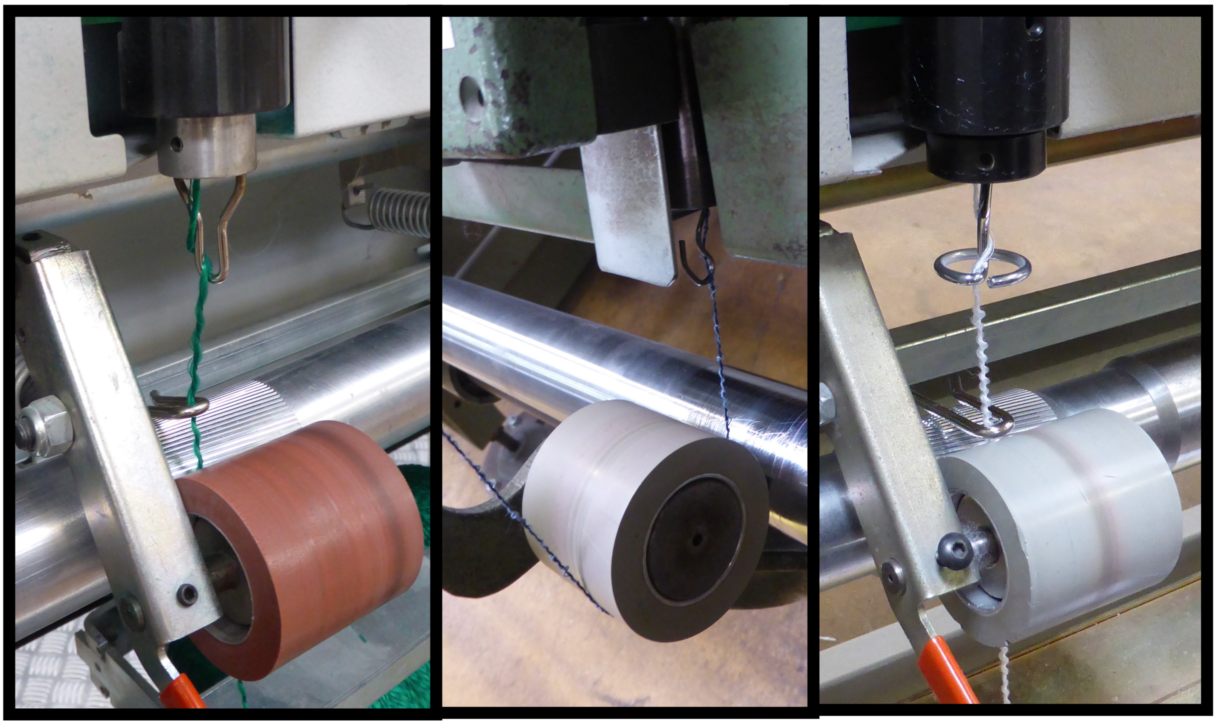

Figure 7.8 *False twist devices.*

8. CONCLUSIONS

Throughout this project several proposals have been made about the different parts of the wrap yarn prototype. However, no choice has been done, as this project is not presented as definitive, but a support for a future construction of the prototype.

In reference to the wrap yarn machine, it has been divided into three distinct parts: the drafting unit, the hollow spindle and the storage unit. Each one has been presented separately with its respective alternatives.

Moreover, no matter which alternatives are being chosen that the prototype will work. Although each proposal has been presented separately, they have been designed in such a way to be able to match with the rest of the alternatives. For this reason, it can be said that the aim of the project, designing a prototype capable of creating a specific type of yarn, has been achieved.

The purpose of the project is that in the future, the person interested on doing the prototype, may choose freely the solution that bests suits their needs from a wide range of proposals given.

The duration of the project has been of approximately four months, a short period in which it has been necessary, for the writer, to be familiarized with the subject of the project. This step has been fundamental to progress successfully along the project, as the knowledge about the subject at the beginning was limited. However, this aspect has conditioned the time for developing the project, as only after being well informed has been possible to start the research.

During this project it has also been used the knowledge acquired throughout the studies of the writer. In order to make the design of the prototype different skills of the writer have been useful: mechanical, technological, innovative, and entrepreneurial.

Finally, it has been an opportunity for the writer to increase her knowledge in an engineer domain never treated before.

9. ACKNOWLEDGEMENTS

I highly appreciate the dedication of the supervisor of this project, Mr. Artan Sinoimeri, as well as, the companies visited, *Schappe Techniques* and *Bergère de France SA.*

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DR. HERBERT STALDER. *The Rieter Manual of Spinning. Volume 6 – Alternative Spinning Systems.* Winthertur: 2014.

11. ANNEX

11.1 FALSE TWIST

Introducing a false twist to a yarn permits increasing the strength of it. Hereafter the principle in which the false twist is based on will be explained.

The next picture shows a yarn nipped by two pairs of rollers: *A* and *B,* charged of driving the filament at a speed of V_d (m/min). At the same time the yarn is twisted at a rate of N_s (rpm) at point *X*. If the twisting device is rotating in clockwise direction, the AX section will turn clockwise (Z-twist), while the other section of the yarn will turn counter clockwise (S-twist).

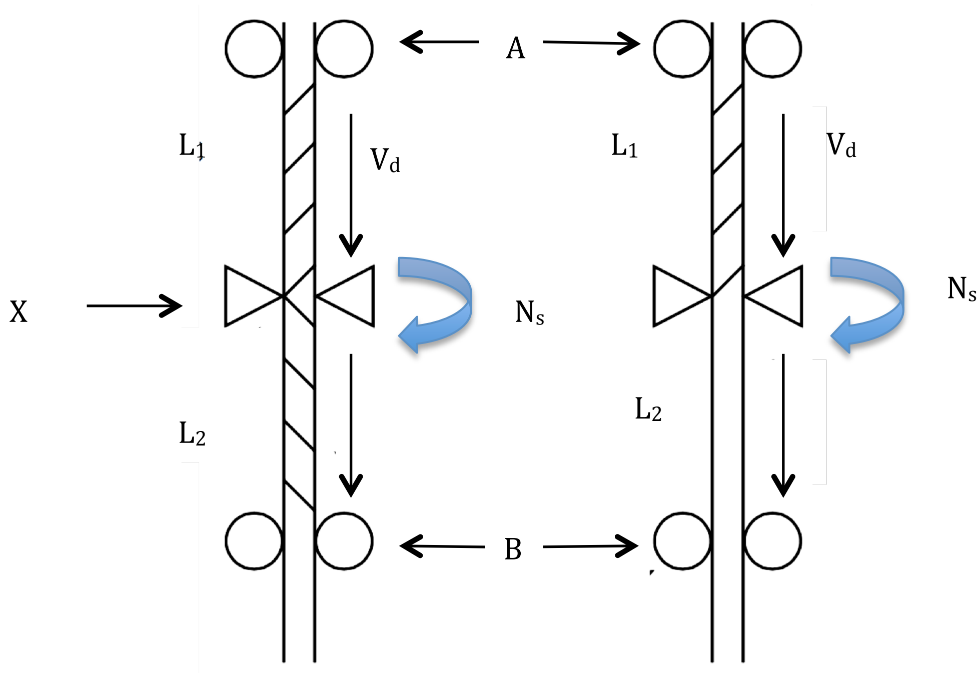


Figure 11.1 *False twist insertion.*

As time passes, the Z-twist present in *AX* zone will increase to a constant value of N_s/V_d. However, in section *XB*, the S-twist will increase to a maximum value and then will decrease to zero. This happens because each part of yarn moving from *AX* to *XB* will become untwisted by the counter clockwise torque applied at point *X*.

The twist of the yarn will evolve according to the next equations, being T_1 the twist that takes place in L_1 and T_2 the twist in L_2.

$$T_1(rev/_m) = \frac{N_S}{V_d} \cdot \left(1 - e^{\frac{-V_d}{L_1} \cdot t}\right) \quad \text{(Eq. 11.1)}$$

$$T_2(rev/_m) = \frac{N_S}{V_d} \cdot \frac{L_1}{L_1 - L_2} \cdot \left(e^{-\frac{V_d}{L_2} \cdot t} - e^{-\frac{V_d}{L_1} \cdot t}\right) \quad \text{(Eq. 11.2)}$$

Moreover, the next graph will show the evolution of the torsion by certain values.

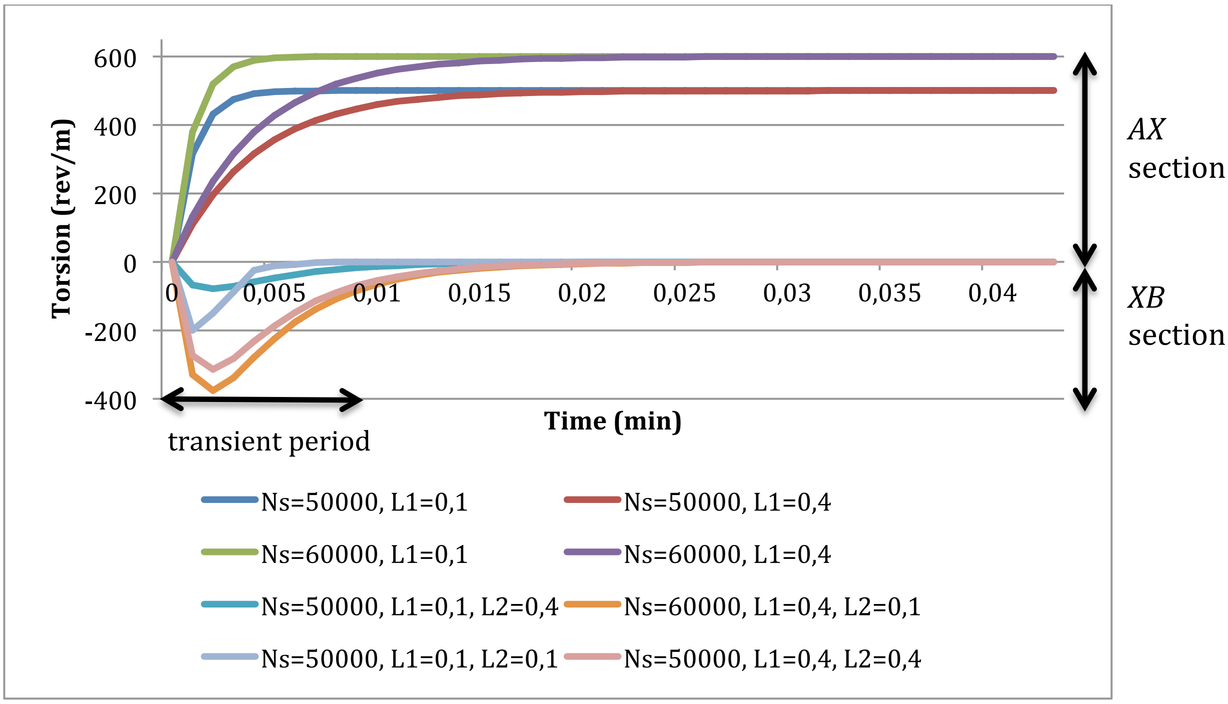


Figure 11.2 Torsion graphic according to time

The time over which the Z-twist builds up to its constant value and the S-twist increases and then decreases to zero is known as the *transient period*. After this period the system is in equilibrium. This twisting action is called false-twisting because, under dynamic equilibrium, the yarn, although being twisted, has no twist when it leaves the twisting device.

With a constant speed (V_d=*cnt*) the transient period that concerns the *AX* period, will increase as length L_1 increases, as it can be seen on the top half of the graph. So, with a same length, and of course the same speed, the degree of torsion will depend on the N_s. the higher N_s it is, the higher the false twist will be.

Focusing now on the transient period of the *XB* section, this becomes smaller when reducing the N_s and as well when reducing the length L_1 and the length L_2.

False-twist can be applied to the fibre ribbon in different ways. A common device is the next one:

Figure 11.3 *False twist unit. Fundamentals of spun yarn technology.*

This type of device can be located whether at the top or at the bottom of the hollow spindle. If situated at the top, the twist propagates to the end of the drafting rollers. While if placed at the bottom the twist propagates to the storing rollers.

Another type of false twist device is the one found in the machine ParafiL from the *Suessen* enterprise. The hollow spindle of this machine incorporates the false twist device. The fibre ribbon does not pass directly through the spindle vertically; instead, after entering the spindle, the strand is led out again and back around the spindle, with a wrap of about one-quarter of the spindle periphery. Thanks to the rotation of the spindle the yarn receives a twist between the drafting unit and the head of the hollow spindle. Afterwards, the twist is cancelled in accordance with the false-twist principle. Hereafter a picture of the mechanism will be shown.

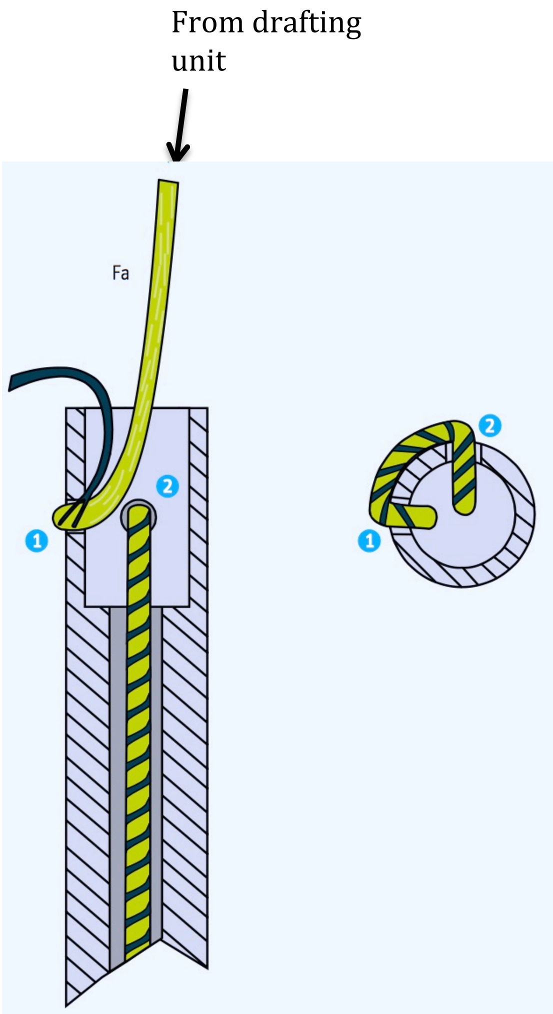


Figure 11.4 *False-twist device in the ParafiL machine. The Rieter Manual of Spinning - volume 6.*

11.2 ENGINE CHARACTERISTICS (BSH0551P01A2A)

Fiche produit
Caractéristiques

BSH0551P21A2A

servo-moteur CA BSH - 0,5N.m-8000tr/mn

- arbre non taraudé - sans frein - IP65

Principale

Statut commercial	Commercialisé
Type de produit ou de composant	Moteur autopiloté
Nom abrégé d'appareil	BSH
Vitesse mécanique maximum	9000 Tr/mn
Couple continu à l'arrêt	0.5 N.m pour LXM32.U60N4 1.5 Aà 480 V triphasé 0.5 N.m pour LXM32.U60N4 1.5 Aà 400 V triphasé 0.5 N.m pour LXM15LU60N4à 230 V triphasé 0.5 N.m pour LXM15LD13M3à 230 V monophasé
Couple crête à l'arrêt	1.5 N.m pour LXM32.U60N4 1.5 Aà 480 V triphasé 1.5 N.m pour LXM32.U60N4 1.5 Aà 400 V triphasé 1.4 N.m pour LXM15LU60N4à 230 V triphasé 1.4 N.m pour LXM15LD13M3à 230 V monophasé
Puissance de sortie nominale	300 W pour LXM32.U60N4 1.5 Aà 480 V triphasé 300 W pour LXM32.U60N4 1.5 Aà 400 V triphasé 170 W pour LXM15LU60N4à 230 V triphasé 170 W pour LXM15LD13M3à 230 V monophasé
Couple nominal	0.48 N.m pour LXM32.U60N4 1.5 Aà 480 V triphasé 0.48 N.m pour LXM32.U60N4 1.5 Aà 400 V triphasé 0.46 N.m pour LXM15LU60N4à 230 V triphasé 0.46 N.m pour LXM15LD13M3à 230 V monophasé
Vitesse nominale	6000 tr/mn pour LXM32.U60N4 1.5 Aà 480 V triphasé 6000 tr/min pour LXM32.U60N4 1.5 Aà 400 V triphasé 4000 tr/mn pour LXM15LU60N4à 230 V triphasé 4000 tr/min pour LXM15LD13M3à 230 V monophasé
Compatibilité produit	LXM32.U60N4à 480 V triphasé LXM32.U60N4à 400 V triphasé LXM15LU60N4à 230 V triphasé LXM15LD13M3à 230 V monophasé
Extrémité d'arbre	Inexploité
Degré de protection IP	IP67 (avec kit IP67) IP65 (standard)
Résolution du retour vitesse	131 072 points/tour
Frein de parking	Sans
Support de montage	Bride conforme à la norme internationale
Raccordement électrique	Connecteurs orientables à angle droit

Complémentaires

Compatibilité de gamme	Lexium 15 Lexium 32
[Us] tension d'alimentation	480 V
Nombre de phases réseau	Triphasé
Courant continu à l'arrêt	0.73 A
Puissance continue maximum	0.45 W
Courant maximal Irms	2.9 A pour LXM32.U60N4 3.5 A pour LXM15LU60N4 3.5 A pour LXM15LD13M3
Courant permanent maximum	2.9 A

Fréquence de commutation	8 kHz
Second arbre	Sans avec deuxième extrémité d'arbre
Diamètre de l'axe	9 mm
Longueur de l'axe	20 mm
Type de retour	Single turn SinCos Hiperface
Taille bride moteur	55 mm
Nombre de taille moteur	1
Constante de couple	0.7 N.m/Aà 120 °C
Constante de fem arrière	40 V/krpmà 120 °C
Nombre de pôles de moteur	6
Inertie du rotor	0.059 kg.cm²
Résistance du stator	41.8 Ohmà 20 °C
Inductance du stator	71.5 mHà 20 °C
Constante de temps électrique du stator	1.09 msà 20 °C
Force radiale maximale Fr	340 Nà 1000 Tr/mn 270 Nà 2000 Tr/mn 240 Nà 3000 Tr/mn 220 Nà 4000 Tr/mn 200 Nà 5000 Tr/mn 190 Nà 6000 Tr/mn 180 Nà 7000 Tr/mn 170 Nà 8000 Tr/mn
Force axiale maximale Fa	0,2 x Fr
Type de refroidissement	Convection naturelle
Longueur	132.5 mm
Diamètre de collier de centrage	40 mm
Profondeur de collier de centrage	2 mm
Nombre de trous de fixation	4
Diamêtre des trous de fixation	5.5 mm
Diamêtre des trous de fixation	63 mm
Masse du produit	1.2 kg

Caractéristiques environnementales

Statut environnemental	Produit Green Premium
RoHS (code date: AnnéeSemaine)	Compliant - since 1018 - Schneider Electric declaration of conformity Déclaration de conformité Schneider Electric
REACh	Reference not containing SVHC above the threshold
Profil environnemental du produit	Disponible Télécharger Profil Environnemental Produit
Instruction fin de vie du produit	Pas d'opération de recyclage spécifiques

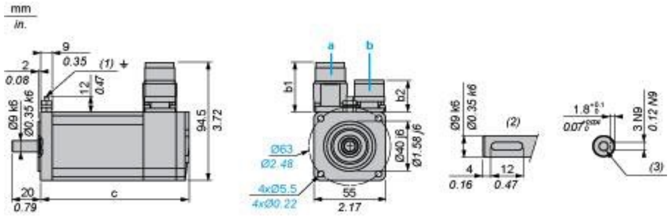
Garantie contractuelle

Période	18 mois

Dimensions Drawings

Servo Motors Dimensions

Example with Straight Connectors



a: Power supply for servo motor brake
b: Power supply for servo motor encoder
(1) M4 screw
(2) Shaft end, keyed slot (optional)
(3) For screw M3 x 9 mm/M3 x 0.35 in.

Dimensions in mm

Straight connectors		Rotatable angled connectors		c (without brake)	c (with brake)
b	b1	b	b1		
39.5	25.5	39.5	39.5	132.5	159

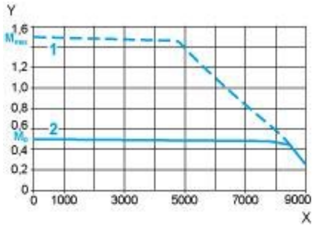
Dimensions in in.

Straight connectors		Rotatable angled connectors		c (without brake)	c (with brake)
b	b1	b	b1		
1.55	1.00	1.55	1.55	5.21	6.25

400 V 3-Phase Supply Voltage

Torque/Speed Curves

Servo motor with LXM32•U60N4 servo drive

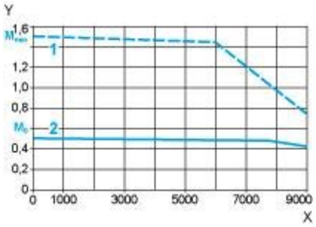


X Speed in rpm
Y Torque in
Nm 1 Peak torque
2 Continuous torque

480 V 3-Phase Supply Voltage

Torque/Speed Curves

Servo motor with LXM32•U60N4 servo drive



X Speed in rpm
Y Torque in
Nm 1 Peak torque
2 Continuous torque

11.3 REDUCER CHARACTERISTICS (GBX060008K)

Fiche Produit
Caractéristiques

GBX060008K

réducteur planétaire droit GBX - Ø 60 mm - réduction 8:1 < 10 arc.min - 18 N.m

Principale

Statut commercial	Commercialisé
Compatibilité de gamme	Lexium ILA Lexium ILS Lexium SD3 Lexium 32 Lexium 28
Type de produit ou de composant	Réducteur planétaire
Type de réducteur	Denture droite
Nom abrégé d'appareil	GBX
Compatibilité produit	BCH2 (60 mm, 2 taille moteur) BCH2 (60 mm, 1 taille moteur) ILS (57 mm, 3 taille moteur) ILS (57 mm, 2 taille moteur) ILS (57 mm, 1 taille moteur) ILA (57 mm, 2 taille moteur) ILA (57 mm, 1 taille moteur) BRS3 BSH (70 mm, 1 taille moteur) BSH (55 mm, 3 taille moteur) BSH (55 mm, 2 taille moteur) BSH (55 mm, 1 taille moteur) BMH (70 mm, 1 taille moteur)
Diamétre externe réducteur	60 mm
Ratio réducteur	8:1

Complémentaires

Jeu de torsion	< 10 arc.min
Rigidité de torsion	2.3 N.m/arcmin
Couleur du logement	Noir
Matière du boîtier	Aluminium anodisé noir
Matière de l'axe	C 45
Information complémentaire	Lubrifié pendant toute la durée de vie
Durée de vie en heures	30000 Hà 100 Tr/mnà 30 °C
Position de montage	Toutes positions
Rendement	96 %
Force radiale maximale Fr	340 Nà 100 Tr/mn, force appliquée à mi-distance de l'arbre de sortie pendant 30 000 heures à 30 °C
Force axiale maximale Fa	450 Nà 100 Tr/mn, pendant 30000 heures à 30 °C
Monent d'inertie	0.065 kg.cm²
Couple de sortie continu	18 N.mà 100 Tr/mnà 30 °C
Couple de sortie maximal	29 N.mà 100 Tr/mnà 30 °C
Masse du produit	0.9 kg

Environnement

Intensité du signal sonore	58 dBà 1 m, sans charge
Degré de protection IP	IP54 sur arbre de sortie
Température ambiante de fonctionnement	-25...90 °C

Caractéristiques environnementales

Statut environnemental	Produit Green Premium
RoHS (code date: AnnéeSemaine)	Compliant - since 1129 - Schneider Electric declaration of conformity Déclaration de conformité Schneider Electric
REACh	Reference not containing SVHC above the threshold
Profil environnemental du produit	Disponible Télécharger Profil Environnemental Produit
Instruction fin de vie du produit	Pas d'opération de recyclage spécifiques

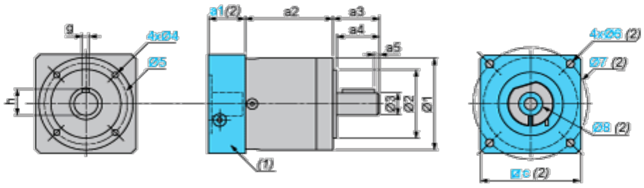
Garantie contractuelle

Période	18 mois

Fiche Produit
Dimensions Drawings

GBX060008K
réducteur planétaire droit GBX - Ø 60 mm - réduction 8:1 < 10 arc.min - 18 N.m

Dimensions with Servo Motor Adaptation Kit



(1) GBK adaptation kit
(2) GBK adaptation kit related dimensions a1, c, Ø6, Ø7, Ø8 depend on the gearbox and servo motor combination
Ø8 shaft end adaptor in case motor shaft diameter is smaller than gearbox input coupling diameter

Values in mm

a2	a3	a4	a5	h	g	Ø1	Ø2	Ø3	Ø4	Ø5
55	35	30	2.5	16	5	60	40 h7	14 h7	M5 x 8	52

Values in in.

a2	a3	a4	a5	h	g	Ø1	Ø2	Ø3	Ø4	Ø5
2.16	1.38	1.18	0.10	063	0.19	2.36	1.57 h7	0.55 h7	M5 x 0.31	2.05

11.4 DRIVE CHARACTERISTICS (LXM32AU60N4) AND (LXM32MU60N4)

Fiche produit
Caractéristiques

LXM32AU60N4
LXM32A INTERFACE CAN RJ45 6A RMS CRETE 3PH 480V

Principale

Statut commercial	Commercialisé
Gamme de produits	Lexium 32
Type de produit ou de composant	Servo variateur pour commande de mouvement
Nom abrégé d'appareil	LXM32A
Format du lecteur	Livre
Nombre de phases réseau	Triphasé
[Us] tension d'alimentation	380...480 V (- 15...10 %) 200...240 V (- 15...10 %)
Limites de la tension d'alimentation	170...264 V 323...528 V
Fréquence d'alimentation	50/60 Hz (- 5...5 %)
Fréquence du réseau	47,5...63 Hz
Filtre CEM	Intégré
Courant de sortie permanent	1.8 A (f = 8 kHz)
Courant de sortie de crête 3s	6 A pour 5 s
Alimentation continue	800 Wà 400 V 400 Wà 230 V
Puissance nominale	0.4 kWà 400 V (f = 8 kHz) 0.35 kWà 230 V (f = 8 kHz)
Courant de ligne	1.8 A, THDI of 187 %à 380 V, without line choke 1.2 A, THDI of 201 %à 480 V, without line choke 1.6 A, THDI of 116 %à 480 V, with external line choke de 2 mH 1.9 A, THDI of 106 %à 380 V, with external line choke de 2 mH

Complémentaires

Fréquence de commutation	8 kHz
Catégorie de surtension	III
Courant de fuite	< 30 mA
Tension de sortie	<= power supply voltage
Isolation électrique	Entre alimentation et contrôle
Type de câble	Câble IEC monobrin (pour θ = 50 °C) matériau conducteur: cuivre 90°C ,matériau isolant des fils: XLPE/EPR
Raccordement électrique	Bornier câble 5 mm² AWG 10 (CN10) Bornier câble 5 mm² AWG 10 (CN1) Bornier câble 3 mm² AWG 12 (CN8)
Couple de serrage	0.7 N.m (CN10) 0.7 N.m (CN1) 0.5 N.m (CN8)
Nombre entrées TOR	4 logique 2 sécurité 1 capture
Type d'entrée TOR	Sécurité (complément de STO_A, complément de STO_B) Logique (DI) Capture (capuchon)
Durée d'échantillonnage	0.25 ms (DI) pour numérique
Tension entrées TOR	24 V c.c. pour sécurité 24 V c.c. pour logique

Logique d'entrée numérique	Positif ou négatif (DI) à l'état 0: < 5 V à l'état 1: > 15 V conformément à EN/IEC 61131-2 type 1 Positif (DI) à l'état 0: > 19 V à l'état 1: < 9 V conformément à EN/IEC 61131-2 type 1 Positif (complément de STO_A, complément de STO_B) à l'état 0: < 5 V à l'état 1: > 15 V conformément à EN/IEC 61131-2 type 1
Temps de réponse	<= 5 ms (complément de STO_A, complément de STO_B)
Nombre sorties TOR	2
Type de sortie TOR	Logique (DO) 24 V DC
Tension de sortie TOR	<= 30 V DC
Logique sortie TOR	Positif ou négatif (DO) conformément à EN/IEC 61131-2
Durée des rebonds de contact	0.25 µs...1.5 ms (DI) 2 µs (capuchon) <= 1 ms (complément de STO_A, complément de STO_B)
Courant de freinage	50 mA
Temps de réponse de la sortie	250 µs (DO) numérique
Type de signal de commande	Retour codeur servo-moteur
Type de protection	Contre les courts-circuits :signal de sorties Contre l'inversion de polarité :signal d'entrée
Fonction de sécurité	STO (safe torque off), intégré
Niveau de sécurité	PL = e conformément à ISO 13849-1 SIL 3 conformément à EN/IEC 61508
Interface de communication	Intégré Modbus Intégré CANopen Intégré CANmotion
Type de connecteur	RJ45 (repère CN7) :Modbus RJ45 (repères CN4 ou CN5) :CANopen RJ45 (repères CN4 ou CN5) :CANmotion
Méthode d'accès	Esclave
Interface physique	RS485 multipoint à 2 fils Modbus
Vitesse de transmission	9600, 19200, 38400 bps pour une longueur de bus de <= 40 m Modbus 500 kbps pour une longueur de bus de <= 100 m CANopen, CANmotion 50 kbps pour une longueur de bus de <= 1000 m CANopen, CANmotion 250 kbps pour une longueur de bus de <= 250 m CANopen, CANmotion 125 kbps pour une longueur de bus de <= 500 m CANopen, CANmotion 1 Mbps pour une longueur de bus de <= 4 m CANopen, CANmotion
Nombre d'adresses	1...247 Modbus 1...127 CANopen, CANmotion
Service communication	Sync CANmotion Mode positionnement, vitesse, couple et prise d''origine CANopen Mode positionnement CANmotion Garde de notes, battement de cœur CANopen Déclenchement selon événement/temps, demande à distance, sync cyclique/acy-clique CANopen Urgence CANopen, CANmotion Affichage d''erreurs sur terminal intégré Modbus Entraînement d''équipement et commande de mouvement CANopen CANopen, CANmotion 4 PDO mappés configurables CANopen 2 SDO émetteurs CANopen 2 SDO récepteurs CANopen 2 PDO conformes à la norme DSP 402 CANmotion 1 SDO en transmission CANmotion 1 SDO en réception CANmotion
LED d'état	1 LED RUN 1 LED erreur 1 LED (rouge) tension dans le servo-variateur
Fonction de signalisation	Affichage des défauts in 7 segments
Marquage	CE
Position de montage	Vertical +/- 10 degree
Compatibilité produit	Servo motor BSH (55 mm, 2 motor stacks) Servo motor BSH (55 mm, 1 motor stacks) Servo motor BSH (55 mm, 3 motor stacks) Servo motor BMH (70 mm, 1 motor stacks)
Largeur	48 mm Hauteur 270 mm

Environnement

Compatibilité électromagnétique	CEM rayonnéeà category C3 conformément à EN/IEC 61800-3 CEM rayonnéeà class A group 2 conformément à EN 55011 Test d'immunité des transitoires rapides/salves électriquesà level 4 conformément à EN/IEC 61000-4-4 Test d'immunité aux ondes de choc 1,2/50 µsà niveau 3 conformément à EN/IEC 61000-4-5 Susceptibilité aux champs électromagnétiquesà niveau 3 conformément à EN/IEC 61000-4-3 Test d'immunité de décharge électrostatiqueà niveau 3 conformément à EN/IEC 61000-4-2 Tests CEM réalisésà environments 1 and 2 conformément à EN/IEC 61800-3 Tests CEM réalisésà category C2 conformément à EN/IEC 61800-3 Tests CEM réalisésà environment 2 category C3 conformément à EN/IEC 61800-3 Tests CEM réalisésà class A group 2 conformément à EN 55011 Tests CEM réalisésà groupe 1, classe A conformément à EN 55011
Normes	EN/IEC 61800-3 EN/IEC 61800-5-1
Certifications du produit	CSA RoHS TÜV UL
Degré de protection IP	IP20 conformément à EN/IEC 61800-5-1 IP20 conformément à EN/IEC 60529
Tenue aux vibrations	1,5 mm crête-à-crête (f = 3...13 Hz) conformément à EN/IEC 60068-2-6 1 gn (f = 13...150 Hz) conformément à EN/IEC 60068-2-6
Tenue aux chocs mécaniques	15 gn pour 11 ms conformément à EN/IEC 60028-2-27
Niveau de pollution	2 conformément à EN/IEC 61800-5-1
Caractéristique d'environnement	Classes 3C1 conformément à IEC 60721-3-3
Humidité relative	Classe 3K3 (5 à 85 %) sans condensation conformément à IEC 60721-3-3
Température de fonctionnement	0...50 °C conformément à UL
Température ambiante pour stockage	-25...70 °C
Type de refroidissement	Convection naturelle
Altitude de fonctionnement	> 1000...3000 m Avec conditions <= 1000 m sans facteur de déclassement

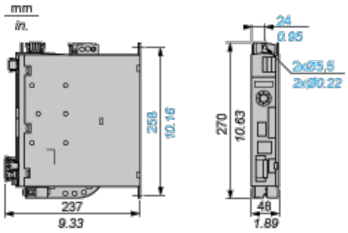
Caractéristiques environnementales

Statut environnemental	Produit non Green Premium
RoHS (code date: AnnéeSemaine)	Compliant - since 0930 - Schneider Electric declaration of conformity Déclaration de conformité Schneider Electric
REACh	Reference not containing SVHC above the threshold
Profil environnemental du produit	Disponible Télécharger Profil Environnemental Produit

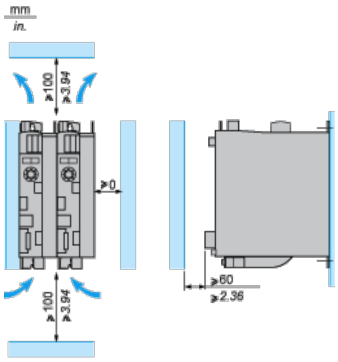
Garantie contractuelle

Période	18 mois

Dimensions



Mounting Recommendations



LXM32•U45M2, •U90M2 and LXM32•U60N4 servo drives are cooled by natural convection. LXM32•D18M2, •D30M2, LXM32 •D12N4, •D18N4, •D30N4 and •D72N4servo drives have an integrated fan.

When installing the servo drive in the enclosure, follow the instructions below with regard to the temperature and protection index:

- Provide sufficient cooling of the servo drive
- Do not mount the servo drive near heat sources
- Do not mount the servo drive on flammable materials
- Do not heat the servo drive cooling air by currents of hot air from other equipment and components, for example from an external braking resistor
- Mount the servo drive vertically (± 10%)
- If the servo drive is used above its thermal limits, control stops due to overtemperature

NOTE: For cables that are connected via the underside of the servo drive, a free space ≥ 200 mm/7.87 in. is required under the unit to comply with the bending radius of the connection cables.

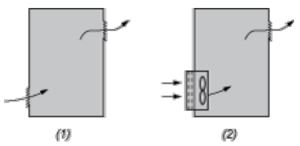
Ambient temperature	Mounting distances	Instructions to be followed
0°C…+ 50°C	d ≥ 0 mm	–
+ 50°C…+ 60°C	d ≥ 0 mm	Reduce the output current by 2.2% per °C above 50°C

NOTE: Do not use insulated enclosures, as they have a poor level of conductivity.

Recommendations for Mounting in an Enclosure

To ensure good air circulation in the servo drive:

- Fit ventilation grilles on the enclosure.
- Ensure that ventilation is adequate, otherwise install a forced ventilation unit with a filter.



(1) Natural convection
(2) Forced ventilation

- Any apertures and/or fans must provide a flow rate at least equal to that of the servo drive fans (refer to characteristics).
- Use special filters with IP 54 protection.

Mounting in Metal Enclosure (IP 54 Degree of Protection)

The servo drive must be mounted in a dust and damp proof enclosure in certain environmental conditions, such as dust, corrosive gases, high humidity with risk of condensation and dripping water, splashing liquid, etc. In these cases, Lexium 32 servo drives can be installed in an enclosure where the internal temperature must not exceed 60°C.

Fiche produit
Caractéristiques

LXM32MU60N4
LXM32 MODULAR 6A RMS CRETE 3PH 480V

Principale

Statut commercial	Commercialisé
Gamme de produits	Lexium 32
Type de produit ou de composant	Servo variateur pour commande de mouvement
Nom abrégé d'appareil	LXM32M
Format du lecteur	Livre
Nombre de phases réseau	Triphasé
[Us] tension d'alimentation	380...480 V (- 15...10 %) 200...240 V (- 15...10 %)
Limites de la tension d'alimentation	170...264 V 323...528 V
Fréquence d'alimentation	50/60 Hz (- 5...5 %)
Fréquence du réseau	47,5...63 Hz
Filtre CEM	Intégré
Courant de sortie permanent	1.5 A (f = 8 kHz)
Courant de sortie de crête 3s	6 A pour 5 s
Alimentation continue	800 Wà 400 V 400 Wà 230 V
Puissance nominale	0.4 kWà 400 V (f = 8 kHz) 0.35 kWà 230 V (f = 8 kHz)
Courant de ligne	1.8 A, THDI of 187 %à 380 V, without line choke 1.2 A, THDI of 201 %à 480 V, without line choke 1.6 A, THDI of 116 %à 480 V, with external line choke de 2 mH 1.9 A, THDI of 106 %à 380 V, with external line choke de 2 mH

Complémentaires

Fréquence de commutation	8 kHz
Catégorie de surtension	III
Courant de fuite	< 30 mA
Tension de sortie	<= power supply voltage
Isolation électrique	Entre alimentation et contrôle
Type de câble	Câble IEC monobrin (pour θ = 50 °C) matériau conducteur: cuivre 90°C ,matériau isolant des fils: XLPE/EPR
Raccordement électrique	Bornier câble 5 mm² AWG 10 (CN10) Bornier câble 5 mm² AWG 10 (CN1) Bornier câble 3 mm² AWG 12 (CN8)
Couple de serrage	0.7 N.m (CN10) 0.7 N.m (CN1) 0.5 N.m (CN8)
Nombre entrées TOR	4 logique 2 sécurité 2 capture
Type d'entrée TOR	Sécurité (complément de STO_A, complément de STO_B) Logique (DI) Capture (capuchon)
Durée d'échantillonnage	0.25 ms 0.25 ms (DI) pour numérique

Tension entrées TOR	24 V c.c. pour sécurité 24 V c.c. pour logique 24 V c.c. pour capture
Logique d'entrée numérique	Positif ou négatif (DI) à l'état 0: < 5 V à l'état 1: > 15 V conformément à EN/IEC 61131-2 type 1 Positif (DI) à l'état 0: > 19 V à l'état 1: < 9 V conformément à EN/IEC 61131-2 type 1 Positif (complément de STO_A, complément de STO_B) à l'état 0: < 5 V à l'état 1: > 15 V conformément à EN/IEC 61131-2 type 1
Temps de réponse	<= 5 ms (complément de STO_A, complément de STO_B)
Nombre sorties TOR	3
Type de sortie TOR	Logique (DO) 24 V DC
Tension de sortie TOR	<= 30 V DC
Logique sortie TOR	Positif ou négatif (DO) conformément à EN/IEC 61131-2
Durée des rebonds de contact	0.25 µs...1.5 ms (DI) 2 µs (capuchon) <= 1 ms (complément de STO_A, complément de STO_B)
Courant de freinage	50 mA
Temps de réponse de la sortie	250 µs (DO) numérique
Type de signal de commande	Retour codeur servo-moteur Impulsion/Direction (P/D), A/B, CW/CCW :RS422 (f = <= 1000 kHz) (longueur de câble: 100 m) Impulsion/Direction (P/D), A/B, CW/CCW :Liaison 5 V, 24 V (push-pull) (f = <= 200 kHz) (longueur de câble: 10 m) Impulsion/Direction (P/D), A/B, CW/CCW :Liaison 5 V, 24 V (collecteur ouvert) (f = <= 10 kHz) (longueur de câble: 1 m) Sortie avec train d"impulsion (PTO) :RS422 (f = <= 500 kHz) (longueur de câble: 100 m)
Type de protection	Contre les courts-circuits :signal de sorties Contre l'inversion de polarité :signal d'entrée
Fonction de sécurité	SOS (safe operating stop), avec carte de sécurité eSM séparée SLS (safe limited speed), avec carte de sécurité eSM séparée SS2 (safe stop 2), avec carte de sécurité eSM séparée SS1 (safe stop 1), avec carte de sécurité eSM séparée STO (safe torque off), intégré
Niveau de sécurité	PL = e conformément à ISO 13849-1 SIL 3 conformément à EN/IEC 61508
Interface de communication	Avec carte de communication séparée I/O Avec carte de communication séparée DeviceNet Avec carte de communication séparée Profibus Avec carte de communication séparée EtherCAT Avec carte de communication séparée Ethernet/IP Avec carte de communication séparée CANmotion Avec carte de communication séparée CANopen Intégré Modbus
Type de connecteur	RJ45 (repère CN7) :Modbus
Interface physique	RS485 multipoint à 2 fils Modbus
Vitesse de transmission	9600, 19200, 38400 bps pour une longueur de bus de <= 40 m Modbus
Nombre d'adresses	1...247 Modbus
LED d'état	1 LED (rouge) tension dans le servo-variateur
Fonction de signalisation	Affichage des défauts in 7 segments
Marquage	CE
Position de montage	Vertical +/- 10 degree
Compatibilité produit	Servo motor BSH (55 mm, 2 motor stacks) Servo motor BSH (55 mm, 1 motor stacks) Servo motor BSH (55 mm, 3 motor stacks) Servo motor BMH (70 mm, 1 motor stacks)
Largeur	68 mm
Hauteur	270 mm
Profondeur	237 mm
Masse du produit	1.8 kg

Environnement

Compatibilité électromagnétique	CEM rayonnéeà category C3 conformément à EN/IEC 61800-3 CEM rayonnéeà class A group 2 conformément à EN 55011 Test d'immunité des transitoires rapides/salves électriquesà level 4 conformément à EN/IEC 61000-4-4 Test d'immunité aux ondes de choc 1,2/50 µsà niveau 3 conformément à EN/IEC 61000-4-5 Susceptibilité aux champs électromagnétiquesà niveau 3 conformément à EN/IEC 61000-4-3 Test d'immunité de décharge électrostatiqueà niveau 3 conformément à EN/IEC 61000-4-2 Tests CEM réalisésà environments 1 and 2 conformément à EN/IEC 61800-3 Tests CEM réalisésà category C2 conformément à EN/IEC 61800-3 Tests CEM réalisésà environment 2 category C3 conformément à EN/IEC 61800-3 Tests CEM réalisésà class A group 2 conformément à EN 55011 Tests CEM réalisésà groupe 1, classe A conformément à EN 55011
Normes	EN/IEC 61800-3 EN/IEC 61800-5-1
Certifications du produit	CSA RoHS TÜV UL
Degré de protection IP	IP20 conformément à EN/IEC 61800-5-1 IP20 conformément à EN/IEC 60529
Tenue aux vibrations	1,5 mm crête-à-crête (f = 3...13 Hz) conformément à EN/IEC 60068-2-6 1 gn (f = 13...150 Hz) conformément à EN/IEC 60068-2-6
Tenue aux chocs mécaniques	15 gn pour 11 ms conformément à EN/IEC 60028-2-27
Niveau de pollution	2 conformément à EN/IEC 61800-5-1
Caractéristique d'environnement	Classes 3C1 conformément à IEC 60721-3-3
Humidité relative	Classe 3K3 (5 à 85 %) sans condensation conformément à IEC 60721-3-3
Température de fonctionnement	0...50 °C conformément à UL
Température ambiante pour stockage	-25...70 °C
Type de refroidissement	Convection naturelle
Altitude de fonctionnement	> 1000...3000 m Avec conditions <= 1000 m sans facteur de déclassement

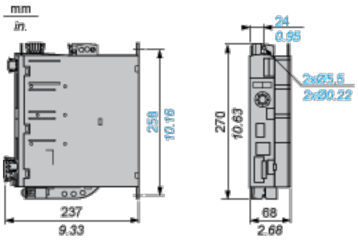
Caractéristiques environnementales

Statut environnemental	Produit non Green Premium
RoHS (code date: AnnéeSemaine)	Compliant - since 0930 - Schneider Electric declaration of conformity Déclaration de conformité Schneider Electric
REACh	Reference not containing SVHC above the threshold
Profil environnemental du produit	Disponible Télécharger Profil Environnemental Produit

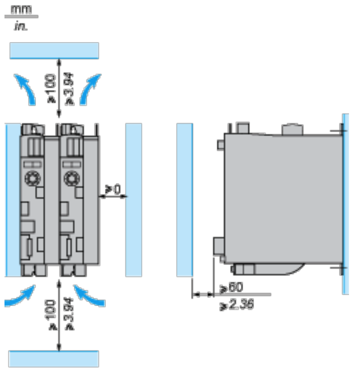
Garantie contractuelle

Période	18 mois

Dimensions



Mounting Recommendations



LXM32•U45M2, •U90M2 and LXM32•U60N4 servo drives are cooled by natural convection. LXM32•D18M2, •D30M2, LXM32 •D12N4, •D18N4, •D30N4 and •D72N4servo drives have an integrated fan.

When installing the servo drive in the enclosure, follow the instructions below with regard to the temperature and protection index:

- Provide sufficient cooling of the servo drive
- Do not mount the servo drive near heat sources
- Do not mount the servo drive on flammable materials
- Do not heat the servo drive cooling air by currents of hot air from other equipment and components, for example from an external braking resistor
- Mount the servo drive vertically (± 10%)
- If the servo drive is used above its thermal limits, control stops due to overtemperature

NOTE: For cables that are connected via the underside of the servo drive, a free space ≥ 200 mm/7.87 in. is required under the unit to comply with the bending radius of the connection cables.

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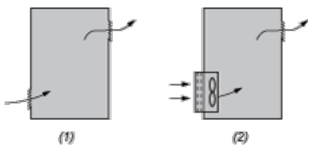

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